5th Workshop on Computational Models of Narrative

CMN'14, July 31–August 2, 2014, Quebec City, Canada

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OASICS

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Preface

Welcome to the Fifth Workshop on Computational Models of Narrative. This year finds us once again co-located with the Annual Meeting of the Cognitive Science Society (CogSci 2014), and again associated with AAAI, in the form of co-location with AAAI-14 and IAAI-14. We are also co-located with the Annual Computational Neuroscience Meeting (CNS 2014). This latter association, along with the end of DARPA's Narrative Networks program, made it convenient to have a special focus on the intersection of neuroscience and narrative. Although this intersection is currently small, I believe we will see much more activity in this areas in coming years, as neuroscience, cognitive science, and cognitive modeling become ever more integrated.

Interest in and submissions to the CMN workshop remain robust. This year we received 27 submissions; of these 7 were accepted outright and 5 were declined. In keeping with our goal of inclusiveness, 14 papers that the reviewers thought contained worthwhile contributions but had (fixable) flaws were accepted on condition of revision. None of these revised papers were declined after revision, although one paper was withdrawn. Including an additional 2 invited works and 1 keynote abstract brings the total number of published works in this proceedings to 24. These numbers have allowed us to reach an important milestone: the CMN workshop series has published exactly *101 works* across its six years, five meetings, and four proceedings volumes! This sustained pace bodes well for the future of the workshop series and the field.

This year we are proud to give the *Award for Best Student Paper on a Cognitive Science Topic* to Oleg Sobchuk of the University of Tartu for his paper "Multilevel Accentuation and its Role in the Memorization of Narrative." Oleg will receive a $250 award, as well as a year's membership in the Cognitive Science Society.

In an effort to ensure the longevity and continued vitality of the workshop series, we will begin a transition period over the next few years from my stewardship to a more formal organizational structure. We will establish a steering committee, comprised of former organizers and co-organizers of the workshop. We will also move to a "staged" organization arrangement, where those who volunteer to be lead organizer of the workshop in year X will help co-organize the workshop in year X-1. This arrangement will not only help new organizers learn the ropes, but help lend continuity to the series.

Many thanks to our generous sponsors without whom this year's workshop would not have been possible: The United States Office of Naval Research Global (ONR-G) again provided funds for the venue and travel grant money; and the Cognitive Science Society funded our best paper award.

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Toward Neurally-Inspired Computational Models of Narrative*

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Abstract

In the spirit of the neuroscience theme of this year's meeting, I will describe a set of cognitive and neurophysiological phenomena that are important for the processing of narrative text at the discourse level. Text processing depends on sequential structure in language and also in the events that language describes. Semantic representations of events capture perceptual and motor properties of described situations, leveraging previous lived experience. Although a large number of neural systems are involved in processing narrative text, a constrained subset of systems are selectively engaged by discourse-level processing. To bring these phenomena together, I will present a simple neurally-inspired computational model of visual event processing that may provide a helpful analogy for some features of language processing.

1998 ACM Subject Classification J.4 Psychology

Keywords and phrases narrative, events, memory, fMRI

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Category Invited Talk

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Narrative in the Operations Process

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Abstract

To counter the threat posed by adversary information activities, the U. S. Army has developed a new warfighting function, "engagement" which will institutionalize lessons learned over the past decade of warfare. Like mission command, sustainment, intelligence, or other warfighting functions that are critical to the successful prosecution of warfare, the ability to engage a population in a way that is credible, logical and emotional to people is far more likely to compel them to the national will than lethal options. The military as a whole, and more specifically the strategic land forces (consisting of the Army, Marine Corps and U. S. Special Operations Command), are now in the process of determining the best way to implement engagement as a full-fledged function of strategic landpower. This paper will make the case that *narrative* is one of the key elements of engagement.

The past ten years of conflict in Iraq and Afghanistan have taught the U. S. military that future wars of the 21st century will be characterized by low intensity conflicts in increasingly complex environments. In spite of the U. S. military's preponderance of power and overwhelming ability to dominate an adversary in traditional maneuver warfare, resilient insurgencies have demonstrated their potential to successfully conduct asymmetric warfare. This has proven successful, at least in the near term, when employed against U. S. and coalition forces. While the military has consistently fulfilled its responsibility to defeat the enemy's conventional forces and seize, occupy and defend land areas, it has not been as successful in the war of ideologies. We will outline how narrative should align to the military decision making process, and give an example of a successful narrative operation (Voices of Moderate Islam) that can serve as vignette for demonstrating how to conduct a narrative in U. S. led operations. We also make the case for greater academic focus on the topic of narrative in a military context: The acceptance of "engagement" as a function of warfare is still premature so a close cooperation is necessary between the military and academic disciplines that study narrative. Collaborative partnerships with academia will be critical. Finally, we argue that the doctrinal institutionalization of narrative as part of the military decision making process (MDMP) will enable military commanders to effectively achieve the desired goals of national policy.

1998 ACM Subject Classification J.7 Computers in Other Systems: Military

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Category Invited Paper

1 Background: Why narrative?

It is hard to argue that the United States' capacity to defeat conventional enemies on a battlefield, or project power overseas, has done anything but increase since the end of the Cold War. Yet, even as the military's ability to conduct traditional "maneuver warfare" has increased, its ability to counter violent extremist messages, in comparison remains less

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developed. Dr. Sebastian Gorka, of the National Defense University, pointed out: "Today we face a foe who knows that wars start with ideas, and depends on them far more than weapons." [1, p. 1] Because of this capability gap, extremist organizations have been able to capitalize on a variety of information to replenish their ranks and sway neutral populations to provide safe havens and materiel support. Insurgents and violent extremists in Iraq, Afghanistan, North Africa, the Pacific and other areas have enjoyed, and still enjoy, a period in which they could spread their ideas.

In 2013, the ground forces of the United States military, consisting of the U. S. Army, the U. S. Marine Corps, and U. S. Special Operations Command collaborated to create the Strategic Landpower Taskforce. The Task Force was designed to analyze the lessons learned in Iraq and Afghanistan and make recommendations on how to rebalance the force to focus on engagement and preventing war. In October of 2013, the taskforce produced its findings in "Strategic Landpower: Winning the Clash of Wills." Endorsed by the heads of each branch, the report acknowledged "the fundamental premise that people are the center of all national engagements, it is equally self-evident that war, or more broadly, conflict, is also an inherently human endeavor." [5, p. 2] As such, technology and overwhelming firepower will not be enough to subdue an enemy insurgency.

Because of this, the concept of "Engagement," as a warfighting function that will be executed across the force, has been accepted as doctrinally necessary. The U. S. Army's functional concept for Engagement is defined as, "the capabilities and skills necessary to work with host nations, regional partners, and indigenous populations in a culturally attuned manner that allows bridging language barriers, opening lines of communication and connections with key political and military leaders in a way that is both immediate and lasting." [8] At present time, the U. S. Army is attempting to integrate the findings of the taskforce into meaningful, actionable doctrine and left wondering what constitutes effective engagement for the conventional force.

To engage a local population in a way that is meaningful, the military must consider the best vehicles to transport information to the target population. As the operational environment becomes increasingly urbanized and communication technology becomes more accessible, the military is left coping with the "rising velocity of communication." [5] One potential capability is the use of narrative in U. S. led operations. Narrative is the mind's default means of understanding making it a natural vehicle for engagement. People have an inherent tendency to explain and understand the world through stories; narrative must be harnessed by the warfighter to reach friendly, opposition or neutral populations in ways that might not otherwise be possible. In cultures or geographic areas that rely heavily on oral traditions, such as societies that historically have lower levels of literacy, narratives are extremely potent at achieving trust and confidence.

Because adversaries maintain the considerable advantage of the ability to draw on a stock of cultural knowledge while executing their own narratives, it becomes crucial that the Department of Defense use all source intelligence to obtain the prevailing narratives. All source intelligence provides the ability to recognize, classify and track narrative communication by adversaries and attribute it to different groups. This becomes even more critical in the battle for words, deeds and images which we believe are the primary ways to deliver a narrative. To rectify this analysis gap, a better understanding of the importance of narrative and its delivery at the most junior level in U. S. led operations is necessary.

2 Principles of narrative for the operational environment

Narrative in a military context is "a brief description of a commander's story used to visualize the effects the commander wants to achieve in the information environment to support and shape their operational environments."[3, pp. 1–4, ¶1–20] The mission narrative should be understood by every warfighter and must provide the context and framework from which warfighters will conduct their engagements. In modern, urban insurgencies, lasting strategic success will not be a function of enemy units eliminated or targets destroyed. A successful strategic outcome rests, as it has since time immemorial, on "winning the contest of wills." [5] This end state can be more effectively accomplished through narrative in U. S. led operations.

Corman *et al.* [2], and others, have proposed that there are three prevailing levels of narrative understanding: a master narrative, local narrative, and personal narrative. The master narrative is a prevailing narrative that spans a very broad population base from which multiple local narratives emerge. The local narratives are more geographically represented as they provide more specific context to the immediate surroundings a population center lives in. From the local narratives emerge personal narratives. These are the stories every individual tells and is expressed through the medium of local and master narratives. Together, these three levels of narrative understand roughly mesh with the strategic, operational and tactical levels of thinking that the military is used to operating within.

If narrative is to be successfully integrated into military operations, or even be its driving force, better attention must be devoted to understanding the principles of narrative development. The strategic (master-level) narrative must flow to the operational (local) level and ultimately down to the tactical level where the individual Soldier on the ground interacts daily with the local population delivering personal narratives. As such, the narratives being crafted at the strategic level must be both internally accepted and externally focused. Even the most credible story will fail to take root if it is not accepted by the storyteller himself. Additionally, the narrative itself must be externally focused and resonate with the local belief system of the audience to be viable for any period of time. Specifically, narratives must contain the three basic elements of communication which has been understood since Aristotle first wrote his principles of rhetoric: they must be credible within pre-existing ideology, touch the individual on an emotional level, and be logical to the local belief system-ethos, pathos, and logos. Without these three elements, narratives will not be sustainable for any length of time and is ultimately destined to fail as a tool of any military importance.

There is little doubt to the effectiveness of a carefully crafted narrative in reaching otherwise closed audiences making the understanding of how to transport the narrative critical to its use in operations. "Understanding the characteristics of narrative transport could not only help with influence and deterrence in terms of the types of messages that may be most effective, but also temporal actionable approaches, when individuals or groups might be more receptive to additional messaging or ideas while in narrative transport." [7, p. 40] A recent paper published by the Strategic Multi-Layer Assessment with the support of the Department of Defense noted the usefulness of harnessing emerging neuroscientific and neurotechnological developments as a tool to influence and deter potential adversaries. The paper noted:

> There is empirical evidence that experiencing a narrative can be transformational, and can induce long-term effects upon audiences' beliefs, attitudes, and behavioral intentions and actions. Therefore, the prudent use of narratives may be a crucial approach through which to influence the beliefs of those who (are predisposed to) disagree with the position espoused in the persuasive message.ix [7, p. 9]

Although the Department of Defense has taken the first steps in collaborating with the scientific community on the topic of "engagement," much closer working relationships need to be forged in order to truly tap into the potential of narrative as a military tool.

3 Operations success through narrative: Voices of Moderate Islam

The use of narrative in operations can be highly effective at shaping the perceptions of a given population. A vignette on how narrative in U. S. led operations can successfully reach a population that otherwise might be difficult to engage is Operation "Voices of Moderate Islam" (VoMI). VoMI, which was executed in Afghanistan in August of 2010, was designed to resonate with pre-existing indigenous narratives and tap into the wider cultural pulse of Afghanistan. The end goal of the program was to counter the adversary's prevailing narrative in order to degrade their recruiting efforts and de-legitimize their local operations. The prevailing narrative in Afghanistan's Logar and Wardak provinces was that the Coalition Forces were attempting to supplant Islam with Christianity. VoMI was built with this in mind and tailored to the goal of using narrative as a vehicle to render a critical thread of the Taliban narrative irrelevant by demonstrating that the US and Coalition Forces were not at war with Islam.

During the operation, Soldiers from the 173rd Airborne Brigade Combat Team accompanied 33 "Afghan Key Communicators" on an Islamic pilgrimage through Jordan en route to Saudi Arabia. These "Key Communicators" were handpicked from the general population to represent a wide swath of Afghan society and included village elders, members of the Afghan National Security Forces, former Taliban reintegrees, and other influential individuals. During the trip, which was planned during the holy month of Ramadan, the Key Communicators performed the rite of Umrah and earned the honorific "Hajji." With this honor bestowed on them through the largesse of their American and Coalition Force partners, the Afghans readily returned to their home villages and began to disseminate unscripted narratives that painted a very different, but credible picture than the one the adversary was providing. For a fraction of the cost of a single aircraft sortie, the United States was able to counter the opposition's prevailing narrative by demonstrating that the Coalition was not attempting to supplant Islam with Christianity, nor was the West at war with Islam. At some point in the operation each participant internalized the coalition message: that multi-national efforts in Afghanistan did not constitute a "war on Islam." Participants in the program had their beliefs fundamentally changed. Many of the Afghans had never left their home villages before, much less traveled on an airplane to a foreign nation. The personal narratives the participants would have and tell for the rest of their lives would then challenge the belief system of every member of their society who believed Coalition Forces were against Islam and in Afghanistan to Spread Christianity. One participant explained the experience: "I can speak for us all when I say, we never knew that American bases here had mosques on them, or that you had Muslim Soldiers in your Army, or that you would allow them to pray, and observe Ramadan. I thought you were only about killing – but now I see so much more." Another participant noted: "This journey is our life. When we return, we will tell others what we saw here, we will tell others what you did for us. Everyone will know of the respect you have shown us."[9, p. 15] Because these men are credible to their society, their story is logical, and it matters to the people the narrative exists. Because the words the participants use line up with the deeds the participants preformed, and they have multiple images documenting their story the narrative spreads.

While VoMI is a memorable example of narrative in U. S. led operations, it is not enough. The human domain is the key terrain in the asymmetric battlefield and to win this terrain, a credible narrative must be consistently delivered to the indigenous population over the length of the campaign, not an individual unit's deployment. Unlike maneuver warfare, in which physical terrain might be won or lost through decisive action, the human domain must be won through consistent and synchronized narratives at all three levels. A strategic (master) narrative, which contains the elements of national interest, must be part of the campaign design. A Operational (local) narrative, which caters to a geographic region, dovetails alongside the strategic narrative at the operational level for tactical commands to plan off of. When that's done the personal narrative, which is most often executed at the tactical level through one-on-one interaction, will be a strategically synced narrative producing effective engagements over a sustained period of time.

4 The way forward: Narrative as part of Military Decision Making Process

A mission narrative is an operation which is planned, resourced and executed with the purpose of delivering a U. S. or coalition narrative in the area of operation and can be implemented into the military decision making processes. Special Operations Forces use narratives in their operations, whereas conventional forces do not because it is not established in Joint or Army doctrine, organization, training, materiel, leadership and education, personnel, and facilities (DOTMLPF) apart from Special Operations Forces. This capability gap severely hinders the conventional forces' ability to engage with local population centers in a meaningful way, thus degrading both mission command [6, p. 1] (defined as the exercise of authority and direction by the commander using mission orders to enable disciplined initiative within the commander's intent to empower agile and adaptive leaders in the conduct of unified land operations) and the national interest in general.

A necessary step toward solving this capability gap is to better understand the problem as it pertains to the conventional force. Partnerships between the Department of Defense and academia are critical in this phase. Great strides are being made in the fields of human psychology, neuroscience, sociology, anthropology and neuro-linguistics. Academics working in these fields have significant elements to contribute to a deeper understanding of the role narrative can play in military operations. Many public and private research universities across the country already operate through contracts with the Defense Department and are being resourced to better understand the science behind narrative in the context of military operations.

As a tool to transport narrative, the power of visual information is often under-utilized in operations. If information operations rely on "words, deeds and images" then equal emphasis needs to be put on training military units to harness imagery in order to convey their narrative. Fortunately, these capabilities already exist within every branch of the armed services. For example, the US Army already trains and fields Combat Documentation and Production Specialists. Major Stewart Brown, the commander of the 55th Signal Company, noted "The power of visual information targeted at a specific audience, provides an extremely powerful tool that leaders must be willing and able to leverage for successful engagements. The recent successful engagements in Jordan supported by Soldiers from the 55th Signal Company (Combat Camera) indicate that not only is this holistic approach to engagement necessary, but the capability is real and available."[1] These Soldiers are equipped with cutting edge audio/visual technology and editing software, and are frequently embedded with special operations and conventional forces today around the world. If the conventional military were to utilize these specialized "Visual Scouts" as combat enablers in addition to combat documenters, they could produce narrative imagery in a much more effective way for the Army with minimal financial investment.

5 Conclusion: Doctrinal changes

Great improvements are being made in the military's ability to convey messages, but more is needed in the future if "Engagement" is to be an effective warfighting function. Case studies, extensive research, analytical tools, narrative-specific intelligence methodology, and most importantly, doctrine, needs to be created if narrative is to be harnessed as a critical element of engagement. Additionally, measures of effectiveness will need to be developed, tested, and implemented to ensure the sustainability of the narrative. In spite of these future challenges, a carefully crafted and disseminated narrative can be a powerful vehicle for engagement. The message, if tailored in a way that has a culturally credible storyteller, will be adopted, assimilated, and spread to the intended audience in a way that other messages could not.

In the end, commanders will need to incorporate a synced narrative into their planning process from the strategic level down to the tactical level. Through a change in doctrine, Battalion and Company commanders will need to understand the narrative that their superiors create and ensure their Soldiers are trained and equipped to disseminate that narrative with words, deeds, and images. Thomas Elkjer Nissen, of the Royal Danish Defence College, noted the implications for operational planning in the Danish Defense Journal Militaert Tidsskrift:

> Based on the premise that a commander receives not only a mission or task, but also an accompanying strategic narrative, Narrative Led Operations start with the commander's intent, which then again drives the operational planning process. To give the narrative the primacy needed, the commander's intent in the planning process, the narrative must be stated in the very beginning of higher levels of planning directive, ideally right after the mission statement, just as the commander in his intent should articulate not only in physical effects, but also in informational effects to be achieved. [4, p. 75]

Narrative in U. S. led operations must be recognized as essential to the successful planning and prosecution of military operations. The doctrinal change will entail growing pains and take time, but ultimately make the conventional Army more successful in the operational environment. It is imperative that both military culture and doctrine refocus on the current enemy, which uses ideology and misinformation as a weapon against U. S. forces. Because strategic culture influences how we view our adversary, it becomes critical to adapt our military culture more rapidly than our opponent does. [1, p. 33] It is only by incorporating mission narrative into every step of the Military Decision Making Process that the actions of the force will be readily understood by the local population and facilitate sustained influence in support of achieving the commander's end-state.

[1] Major Stew Brown. Personal Interview. 18 March 2014.

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What Makes Stories Similar? Report on a Research Project, 2011–2014

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Abstract

We present a survey of the results and findings of the research project *What makes stories similar?* funded by the John Templeton Foundation from October 2011 to May 2014.

1998 ACM Subject Classification H.1.m Models and Principles: Miscellaneous, H.3.1 Content Analysis and Indexing, I.2.7 Natural Language Processing, I.2.4 Knowledge Representation Formalisms and Methods, J.4 Social and Behavioral Sciences, J.5 Arts and Humanities

Keywords and phrases narratives, similarity, empirical studies

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Category Invited Report

1 Overview

In analytic philosophy, the notion of *similarity* has created a great deal of debate [1, 15]. Two entities can be similar in many different respects while being dissimilar in other respects; the philosopher is interested in which of the features according to which entities can be similar or dissimilar are essential in a given situation. This philosophical debate becomes an interesting topic of scientific inquiry when there is a chance to make an intuitive notion of similarity precise and measurable and when different measures of similarity can be compared in their relationship to the actual human practice of narrative similarity judgments.

The research project *What makes stories similar?* funded by the John Templeton Foundation from October 2011 to May 2014 aimed at providing a methodological discussion of measures of similarity for narratives, some candidates for such measures, tools and techniques for comparing the measures, and empirical results using these tools and techniques. Guided by its eponymous question and based on [11, 12], the project aimed to find out whether there are structural (rather than presentational) properties that contribute or even define story similarity, whether they can be expressed in formal representation systems, and how such representations can be empirically tested.

2 People involved

The project *What makes stories similar?* was based at the Universität Hamburg and was coordinated by the second author of the present paper as principal investigator; Carlos

Table 1 The empirical research performed as part of the project *What makes stories similar?* with publication references. There were two more experiments on Lehnert's *Plot Units* [10] and the *Doxastic Preference Framework* of [13, 14] during the March 2013 seminar. These results are as of now unpublished.

Experiment	Date	Language	Paper
Propp I	November 2011	English	[2]
Propp II	December 2011	English	[2]
Queneau I	October 2011	German	[8]
Queneau II	December 2011	German	[8]
Fairy Tales	December 2011	German	[8]
Summaries	January 2012	German	[9]
Eliciting Variation	August to December 2012	English/German	[7]
Propp III	March 2013	English + German	[5]
Propp IV	August 2013	German	[5]

León and the first author of the present paper were researchers on positions funded by the project; Alexander Block, Varun Dwarakanathan, Deniz Sarikaya, and Mira Viehstädt were student assistants funded by the project. In addition to this, the researchers in the project closely collaborated with Rens Bod, Faith Lawrence and Aadil Kurji; the researchers became members of the *Interdisciplinary Center for Narratology* (ICN) at Universität Hamburg and have interacted with the ICN researchers, among others, by co-teaching a two-week course, organizing the workshop *Computational Models of Narrative 2013* (CMN 2013) in Hamburg, and by participating in scientific exchange at the *Narratological Colloquium*.

3 Activities

One of the main activities of the project was to develop a series of experiments listed in Table 1 with pointers to the relevant publications. Since some of the experiments required extensive training of the test subjects, it was natural to link some of the experiments to training courses in formal models of narratives. Deniz Sarikaya organized one such course entitled *Formale Ansätze in der Erzählforschung* at the Universität Hamburg, funded in the programme *StipendiatInnen machen Programm* of the *Studienstiftung des deutschen Volkes*, and the experiment **Propp III** was performed during this course by the authors together with Aadil Kurji. Together with Marco Petris, the authors taught a two-week course entitled *Digitalisierung und Formalisierung von Erzählstruktur* at the *Sommerakademie XV 2013* of the *Studienstiftung des deutschen Volkes* held at Schloss Salem; the experiment **Propp IV** was part of this course. In addition to the experiments listed in Table 1, the project used corpus research [6] and formal modelling [9].

Several intensive work meetings took place: in Amsterdam in October 2011 and in Cambridge in February 2012, when several members of the project were all there as visiting fellows during the programme *Semantics & Syntax* at the *Isaac Newton Institute for Mathematical Science*; furthermore, the project organized a panel session entitled *Computational models of narrative structure* at the conference *Digital Humanities 2012* in Hamburg, the workshop *Computational Models of Narrative 2013* in Hamburg as well as a symposium at the *Annual Meeting of the Cognitive Science Society* (CogSci 2013) in Berlin entitled *Computational and Cognitive Aspects of Narratives*.

The project produced a number of publications [12, 2, 8, 9, 6, 7, 5] in which the findings of the activities mentioned above were published. Some of the experimental results will be documented in future publications. Together with Mark Finlayson and Jan Christoph Meister, the authors of this report edited the CMN 2013 proceedings volume [4]. At the moment, a special issue of *Sprache und Datenverarbeitung*, the major German print journal on computational linguistics, is prepared with contributions by leading researchers in our field.

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A Task Based model for Récit Generation from Sensor Data: An Early Experiment

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Abstract

Automatic story generation is the subject of a growing research effort. However, in this domain, stories are generally produced from fictional data. In this paper, we present a task model used for automatic story generation from real data focusing on the narrative planning. The aim is to generate récits (stories) from sensors data acquired during a ski sortie. The model and some preliminary analysis are presented which suggest the interest of the approach.

1998 ACM Subject Classification I.2.7 Natural Language Processing: Language generation, I.2 Artificial Intelligence:Knowledge Representation Formalisms and Methods

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1 Introduction

Stories are pervasive in everyday life and humans have developed cognitive abilities which are tuned to the production and comprehension of stories. Philosophers, linguists and communication scientists have recognised since the Antiquity the fundamental role of story as primary human communication means [4, 21, 5, 16, 13, 11, 15]. The advantage of story over other communicative modes lies in the availability of various means at the structural and linguistic level to convey temporal and causal information, to allow perspective-taking and framing of events, and to emphasise the most relevant information. It is therefore unsurprising that written and oral stories are the main form in which collections of events are conveyed by humans, whether the intention is to report, explain, illustrate opinions or transmit knowledge. According to the Narrative Paradigm [11], stories are widely used even in technical communication (e. g., medical case histories, reports of engineering faults, forensics) and are central in social interaction to establish and strengthen social groups. Stories are also the discursive basis on which our identity is fleshed out.

Computerised story generation, modelling and analysis has already been the subject of research in Computing Science and has recently emerged as being part of what it is called Computational Narratology [17]. Contrasting with this field of research, our aim is to make story generation from real non-linguistic data possible. Our goal is more precisely to record daily life events from sensors capturing people's location, physiological state or activity and to process this data in order to generate stories of daily activities. The widespread development of lifelogging systems, the dissemination of mobile devices such as smartphones able to sense their environment open the door to these new applications. However, to the best of our knowledge, this has been an under-developed area.

The amount of applications that story-generation from real data could support is very large : social interaction for people with disabilities; education; cultural heritage; publishing

5th Workshop on Computational Models of Narrative (CMN'14).
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news or stories for local communities; or helping patients understand complex medical data about themselves. For instance, robots with enhanced communication capabilities for people lacking social interactions will also benefit from a technology that seeks to simulate basic human communicative abilities [27].

In this paper, we focus on the narrative planning which, in narrative generation system, is in charge of defining the overall structure of the story. The hypothesis is that a narrative plan of a story generated from real world can be abstracted by a task model that can be used to ensure consistency in the planning process. In the creativity domain, narrative planning has often be approached by automated planners which find the possibles sets of actions that change an initial state (beginning of the story) to a final desired state (end of the story) [18, 30] with more of less constraints on characters, objects, etc. [29, 25], or interaction with the users [7, 23]. Another emerging field of research is concerned with automatic learning of narrative structure from annotated corpus such as StoryBank [10] or NarrativeML [17]. Nevertheless, they are based on models build from the fictional literature which are not adapted to the narrative generation from real world data where, for instance, characters or goal does not fit into predefined or stereotyped categories. Some systems, such as Tag2Blog [19] or BabyTalk [20], aim at generating reports of events from real data. However, the produced texts are still far from a story [24]. Our approach based on task model would help to deal with real data that are uncertain and incomplete in order to obtain story-like texts or at least close to a story.

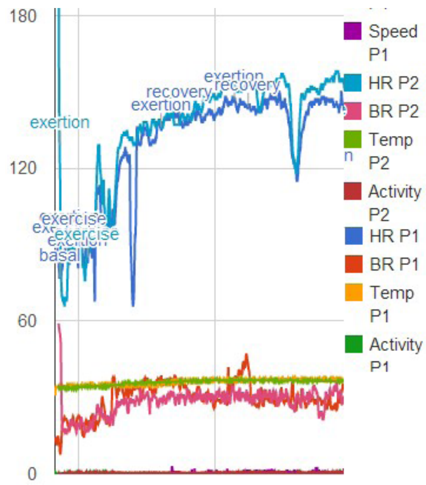
The main application domain of the project is pervasive computing domain, exemplified by smart phones equipped with several different types of sensors, to generate everyday life stories that we call *récits*. More precisely we focus on the ski touring domain which is introduced in Section 2. Section 3 provides some formal definitions regarding the notion of récit and how it is formalized in the proposed approach. Section 4 provides a focus on task-based narrative planning and gives a presentation of the methods and tools involved in this specific step. Early experiments with annotations and an evaluation about them regarding the task-based narrative planning are reported Section 5. The paper finishes with a short discussion on related work and issues to address in further work.

2 Generating stories of ski sorties: main issues

In this paper, we focus on the ski touring. In this sport, skiers go either alone or in team, following a predefined route, to climb in the snow, often in difficult weather conditions. After their sortie, skiers regularly use online portals to share their experiences with their peers in the form of stories (e. g., www.skitour.fr). These stories are intended to help other skiers to organise their sorties and to alert on potential security issues. They combine environmental data (weather, snow conditions, slope…), temporal data and social or evaluative elements. Events, such as route changes, avalanches or accidents are often reported. These stories are framed to give more emphasis on recreational, environmental or emotional aspects, depending on the profile of the writer and also on the experience that has been lived. Hence, this domains is particularly well-suited to récit generation in that it provides a large collection of human stories about their experience, while making raw data collection possible using smart phones which are equipped for the purpose. Figure 1a provides a narrative from the ski touring domain. Physiological and actimetric data were specifically collected for this sortie using two devices (smart phone and physiological sensors). These data involve time, location, altitude, heart and breath rate, etc. An exemple of the collected data is provided in Figure 1b. For details about the data processing the reader is refereed to [20, 31].

10.00, rotten weather, we went to Chamechaude, a usual destination in case of bad weather. In order to add some more climbing, we start 100 m below the Col de Porte, down the lift. The weather is not beautiful, objectively not very cold but we slippers under a fine rain that freezes a bit. We climb quickly and we warm up quickly. Above the rain stopped and I even have the feeling it was too hot in the humid atmosphere! We took only a few breaks, and I do not remember having eat or drink. The snow is pleasant and the track easy to follow up to half of the meadow, then it gets too stiff to our taste and we retrace the end in a thicker snow before attacking the final meters. [Translated from French]

(a)



(b)

Figure 1 Example narrative from the ski touring domain and the corresponding raw data captured along a ski touring activity (two persons involved P1 and P2).

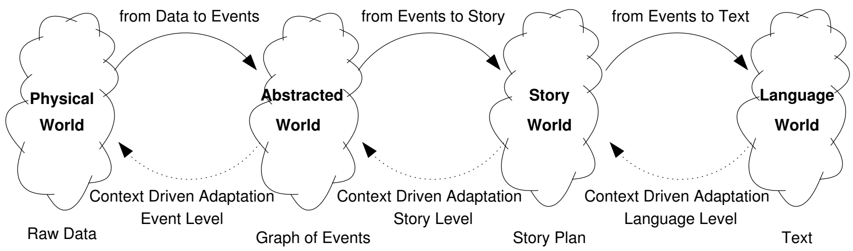


Figure 2 Representation layers for story generation.

Various processing steps are needed to cross the abstraction levels from raw data to full récit generation, as may be seen in Figure 2. We distinguish between (i) the physical world, which is captured through sensors; (ii) the abstracted world, which is an interpretation of the observations captured; (iii) the story world, which is 'one' way of making sense of a subset of the interpretations by choosing, ordering and relating them to each other; and (iv) the natural language world, which is 'one' way of expressing the story world discursively (i. e., the narrative).

Each of these steps raises difficult issues, involving signal processing, data interpretation, event graph construction, story planing and Natural Language Generation (NLG). Viewed from a bottom-up perspective, the processing of raw data involves recognition, inference and/or abstraction. Viewed from the opposite perspective, top-level representations provides framing constraints that gives context to drive the interpretation process, e. g. directing attention to some relevant aspects. This process must be seen as dynamic: the framing evolves as different phases of the story unfold. For instance, elements that are necessary for the introduction can be rendered in a factual manner while more emphasis can be put on external conditions or emotional/personal information, depending on the events occurring in the course of the sortie. For instance, in the example in Figure 1, the fact that few short resting periods are observed during a sortie, might be used as a frame to drive story generation.

In the rest of the paper we focus on core issues of the story planning: what is the structure of a ski touring récit? What are the elements that are relevant to a récit? How to ensure coherence in a récit? This calls for proper models that will provide the skeleton on which the overall process will draw. These elements are described in more details in the following sections.

3 Defining récit

Narrative defines a large amount of different literary forms and artefacts as well as events collections (e. g., narrative in the Event Calculus definition). In this approach, we consider the Mieke Bal's[2] definitions:

> "A *narrative* text is a text in which an agent relates ('tells') a story in a particular medium, [..]. A *story* is a fabula that is presented in a certain manner. A *fabula* is a series of logically and chronologically related events that are caused or experienced by actors. *Actors* are agents that perform actions. [..] To act is defined here as to cause or to experience an *event*."

In our approach, the fabula is the set of connected events that are either directly observed by sensors (i. e., the abstracted world). We call this set the *graph of events* where nodes are particular instance of events and edges are relationships between events. From this graph of events, *scene*s of interest are identified as the atomic components of a *récit plan*.

For Brémond, a récit is a discourse about a succession of events in the same unit of action relevant for humans [5]. Genette suggested that 'récit' indicates the content of the narrative and that 'narrative' is the statements used for communicating the story [14]. The Barthes' definition of récit implies a sequence of events and actions linked by causality [4]. In [1], Adam provides the characteristics of a récit, whether fictional or real with respect to the other kinds of stories. The following definitions are in line with the Adam's perspective.

▶ **Definition 1** (Récit)**.** A real-life *récit* is seen as a sequence of activities with unity of theme and action focused on communicating the actors' experience. It is a succession of events related to facts that have been effectively experienced, observed or captured. In the ski tour context, example events are the tracks actors followed, which dangers were encountered, who was met along their way, etc.

▶ **Definition 2** (Récit Plan)**.** A *récit plan* is a set of selected scenes from the fabula that are ordered and logically related to each other so as to ensure temporal and causal coherence. In ski tour récits, the beginning and end are always identified as the starting point and the ending point of the sortie. Scenes are selected to produce a particular inflection of the fabula.

In this paper, coherence and ordering is ensured by using an *a priori* model based on a task model (cf. Section 4.2). All input data should percolate up to the story through different layers of abstraction, filtering and aggregation constrained by the task model. The planning process should thus be driven by data and knowledge at the same time. One important feature in the récit is the temporal aspect. There is a distinction between the story time and discourse time [9]. Here, the récit presents details and context of scenes in the story time.

▶ **Definition 3** (Scene)**.** A *scene* is the basic temporal unit of récit plan. It belongs to a predefined set of classes of a ski sortie (climbing, resting, observing the environment, etc.) and present a unity of trajectory or location, of activity and of actors.

4 Task-based Récit Planning

In the creativity domain, narrative planning problem is often defined as finding the sequence of character's actions that transforms an initial world state into a world state in which goal propositions hold [25]. However, in the real world, the problem is, given raw data, to extract the scenes that might be connected that can explain the transformation from an initial state to a final state. Important challenges are to be addressed to be able to perform such as planning, such as dealing with the uncertainty and incompleteness in the data. Indeed, while in fictional story, the world is completely defined (e. g., in the phrase "the king's death causes grief to the queen", the consequence of death to cause grief is explicit and thus can be used as the reason for the queen's sorrow) it is incompletely known in real data (e. g., the reason why 'the group had a break' may not be extractable from the data). This incompleteness in the data impacts many other functions of the story generation, such as perspective taking as what a character knows might be unknown.

To account for this uncertainty, the récit planning does not uses crisp logical planning but a task modelling that mostly bases its reasoning on time constraints and preconditions rather than a chain of state transforms in a closed world. The task model does not only ensure consistency of the sequence of scenes but also tolerates a certain amount of incompleteness in the data. This model is particularly well suited to the fields in which the events are relatively constrained (e. g., ski tour, tourism visit, intensive care operations). Other approaches have recognized the power of task modelling for interactive storytelling [7]. The proposed approach for the generation of récit plan relies on two models:

- Domain model: based on an ontology of the domain knowledge, this defines the atomic components of the fabula emerging from the data.
- Récit model: based on a task model which describes actions, schedule, links between tasks and actors

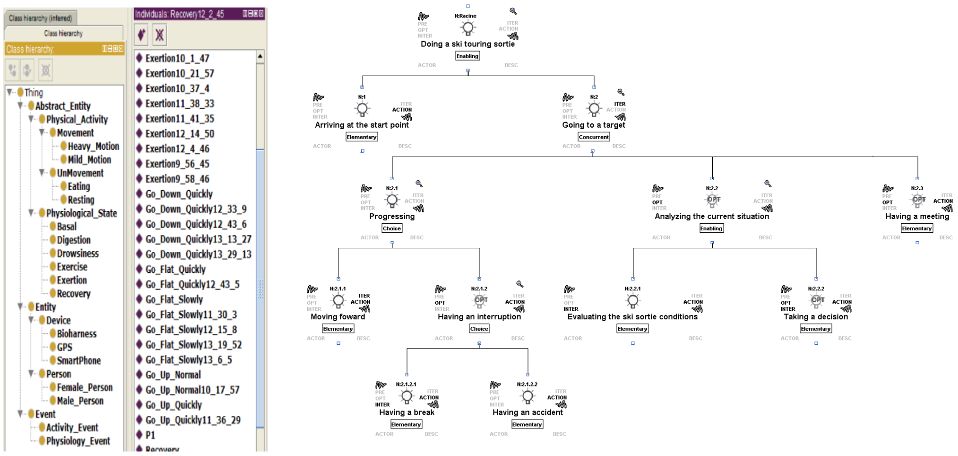
The instances of the ontology and récit are extracted from the actual data according to the model. Thus, a récit plan generated from these data which populate the ontology will be conform to the the task model schedule (here a ski sortie). The two following subsections give more details about these models.

4.1 Ontology

In order to support definition, reasoning and to ensure uniqueness of semantic meaning of the information handled by the different processing step, the domain knowledge was represented by an OWL (Web Ontology Language) ontology. This ontology is expressed in Descriptive Logic (DL) a formal knowledge representation language. In DL, the knowledge is distinguished between the TBox (Terminological Box) and the ABox (Assertional Box). The TBox contains the definition of the concept hierarchies while the ABox contains definitions of the individuals (relations between individuals and concepts). Figure 3a shows an excerpt of the ontology TBox and ABox. The taxonomy is divided into abstract and physical entity as well as event. All events involve at least one entity. For instance physiological events relate one actor with a physiological state at a certain time.

4.2 Task Modelling

Task models have been used for decades in the Human Computer Interaction field (HCI) to express user's activities. It describes how a user acts with interactive systems by hierarchically composing the activities by goals and sub-goals. Thus, a task model describes human activity



(a) (b)

Figure 3 (a) Domain Ontology in OWL (b) the task model employed to support récit planning.

by composition of actions (i. e., tasks) that are linked by abstraction level and temporal relations. Several notations have been developed to express task models [3] which highlight different activity points according to the designer's preoccupations [6]. One of them is K-MADe (Kernel of Model for Activity Description environment)[1]. Figure 3 shows the task model in K-MADe currently employed to represent a ski tour récit. In this model, the activities of actors are represented in the form of task trees, from the most general (e. g., 'Doing a ski touring sortie') to the most detailed (e. g., 'Moving forward'). Each task is characterized by an actor (individual, group, system. . .) and associated with objects describing the actor's environment. These objects influence the course of the activity (e. g., snow storm . . .) and can handled by the actors. Constraints between the tasks include 'Enabling' (the task on the left side must precede the task on its right), 'Concurrent' (tasks can be performed in parallel), etc. Thus, this model makes it possible to represent temporal constraints between tasks, dependencies as well as causality. In this model, each récit starts with an introduction ('Arriving at start point'). Then, each scenes consists in going from the current point to another ('Going to the target') till the starting point in a sequential order (cannot be concurrent). Each target task can then be refined into analysing the situation (e. g., checking the weather or the route, keep going or meeting other skiers).

A task is instanced only if the *conditions for execution* are valid (e. g., preconditions). Moreover a task is associated with *side effects* (e. g., postconditions such as creation or removal of objects, events being generated during the execution of the task, etc.). A succession of tasks respecting the expressed constraints and objects values, namely a *scenario*, expresses a specific execution flow of the activity. In this work, a récit plan is represented by a scenario.

The planning problem becomes to build a scenario that respects the task model or more concretely to find a path in the graph of events that respect the task model constraints. Given the incompleteness of the data, in the course of the plan building, missing scenes are identified by the task model. Once identified, the process can either generate an empty event that will be rendered as an ellipsis or discard the path if the scene is mandatory to ensure coherence.

[1] http://www.lias-lab.fr/forge/projects/kmade

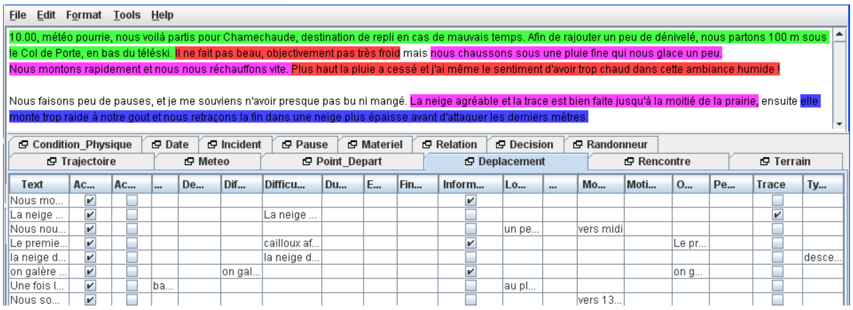


Figure 4 Example of an annotated story using Callisto.

5 Early Experiment

To validate the task model approach, data were extracted from real textual stories written by skiers. These textual stories have been annotated using a schema annotation that has been defined from studies applying the methods used to construct a task model from interviews [28] and from a study identifying the terminology in the field. The annotations are then transformed into scenarios (i. e., an instance of the task model) and checked with the reasoner of K-MADe. Inconsistencies with the model can thus be emphasized.

5.1 Corpus Collection

For the experiment, we collected a few texts from the skitour website (c.f. `www.skitour.fr`). The website offers the opportunity for who practice the ski touring to share their experiences about their journey. Some skiers publish texts containing advices, recommended landscapes, difficulties or, a really important feature, the itinerary of the sortie. Many stories were written as if the author was directly interacting with the reader (recreational conversation, private jokes etc.) and are thus not conform with our definition of a ski tour récit. Thus, "conversational stories" were discarded and the selection was restricted to a few summits. Up to now, 17 texts were selected. We also collected a small parallel corpus consisting in people going for a sortie equipped with sensors (smart-phones and physiological sensors). These people then wrote the récit of their sortie so that most of their experience can be found in the raw data. This corpus will grow to become the main development corpus.

5.2 Annotation

The texts were annotated with the Callisto annotation tool. The software allows the creation of personalized tag-set which are used to annotate the selected phrases with a highlight colour. Callisto employs a Document Type Definition (DTD) to characterise each the tag-set as well as its attributes. The output format file is XML. Figure 4 shows an annotated text (in French, translation can be found in Figure 1a). Each of coloured text segments corresponds to an annotated scene. The elements attributes are put automatically in the lower half of the window in the form of a HTML form (most of them, text fields). It is possible to specify all the attributes of the scene (in the task sense) and to connect each scene to one or several actors. Actors are also annotated in the text. Up to now, 11 texts were annotated.

5.3 First analysis of the annotated texts

During the annotation, some phenomena linked to the nature of human-written text were observed. For instance, some text segments indicate several pieces of information at the same time. This was addressed by labelling several times the same segment (e. g., implicit information about the trajectory in a observation). Moreover, in some cases the narrator decided to omit some details that, however, did not impede the reading. These ellipses were mainly related to trajectory, information that will hopefully be captured by sensors. Others discarded information were references to the past or to the future. Regarding the actors, it was decided to identify the main actor (can be a group) for each récit and to indicate the actor in the scene only when the event was not experienced by the main actor ("we climbed quickly" vs. "I do not remember").

Even if emotional expressions were found in the texts (e. g. surprise, frustration, . . .), the récit structure is mainly a sequential narration of the sortie phases which describe the itinerary followed as well as the environmental conditions (weather and ground characteristics). Recall that the purpose of the récit generation is to generate from sensor data, thus information hard to measure, such as skiers' opinion and emotion are not the focus of the present study. 14 tag types were used for the annotation and from the 11 récits (125 segments), 44% corresponds to a moving forward, 16 % to a terrain description, 10% breaks, 8.8% were meetings, 6.4% mention the starting point. Making a decision and the weather conditions got 5.6% each while checking the physical condition and having an accident got a 0.8% each the 1.6%. Finally, even if all the human aspects exposed were not included in the annotation scheme, we found that the annotation system and their later validation in the K-MADe simulation were capable of capture the itinerary of all the ski touring récits.

5.4 Validation plan of the Task Model

After being annotated, the annotated text was translated into récit plan, that is scenario in the K-MADe format. In this transformation, we assumed that the text order was the chronological order (actually the annotation was performed to make sure this was the case). The purpose was to know if the task model is able to cover all the executed activities in the ski touring. K-MADe has a task editor in which we can set as parameters the activities linked to a specific task and how many times it could be executed. The simulation starts with a point of departure and after that we must choose between all the activities proposed the next one. Each time an activity of a task is chosen, we fill in the attributes with the values that belongs to the activity. Once the simulation done, an XML document containing the succession of tasks chosen with their respective values is obtained. It is the récit plan. This plan is going to be evaluated in a human based experiment to assess the coherence of the final generated texts based on the annotations.

6 Discussion and Future work

The early experiments undertaken in this study suggest that task modelling imposes a flexible domain dependent récit structure and ensures coherence in the way the scenes are organised. However, there are many issues to be addressed to definitely conclude about its relevance. The first issue is related to missing information in the text. For instance some of the scenes are implicit such as in "The snow is pleasant and the track easy to follow up to half of the meadow" where the description of the snow suggests that the group had moved forward. When some scenes are missing (e. g., a decision without explanation) we intend to use ellipses

(i. e., empty task in the task model). How many and what kind of ellipses can be permitted for a human reader is still an open question. Another issue is the lack of information about the temporal aspect in the annotation. Annotation scheme such as TimeML [22] could help capturing important temporal elements in the text. Our work follows a line of research similar to the one that was early developed by Mark Finlayson's StoryBank [10]. As we are not dealing with fictional stories, but rather with real world stories, generated from real world data to represent daily life activities, we were mainly concerned by a dedicated dimension of annotation that we might called "task-driven", a part of the "Plans and Goals". As discussed by him, other dimensions for annotation should be considered in further research. The specificity of Daily life récits in this respect should be studied in depth.

An important step will be the text generation. The approach will be a simple translation of the scenes and their links in order to help system evaluation by humans. However, the most interesting issues will be the study of the dependences between the récit generation layers for dealing with uncertainty in the data. For instance if a break is identified with a low confidence, the récit planning might not take it into account or might include it as justification for an other scene then the NLG part would express this uncertain using modals or other linguistic means (e. g., "the group discussed a lot may be during a break") [12]. The evaluation of the récit planning will be a big issue in the project. Though recent attempt to approach this challenge methodologically (see for instance [26]) there is no consensus. In this study, we will introduce simulation techniques involving stories of varying complexity built at different levels of detail and abstraction. The validation will be conducted in a qualitative manner, by human "experts" and "naive" participants. These assessments will also validate narrative and linguistic choices according to the user model. Indeed a naive participant will not look at the same events and will not use the same language as an expert. Probably one of the most decisive parts is the long term is the data processing that will be put in place. We plan to perform data abstraction based on an hybrid top-down bottom-up approach based on statistical models and logical model to recognized a set of high-level scenarios in physiological data [31] as well as on statistical-relational models which were used to recognize human activities from pervasive sensors [8]. With this approach, raw data would be abstracted in a graph of events logically and probabilistically linked.

Our work is comparable to others that are focused on computational narrative structure representations, such as the Hierarchical Task Networks planning (HTN). In this work, the HTN has been applied to storytelling [7] to structure a story through the decomposition of a main task in subtasks. However, while the authors in [7] are interested by the emergence of story variants from the interaction of autonomous actors, we are rather interested by the emergence of story variants from the interaction between a planned activity, with some a priori known starting and ending point (the car park and the summit) and a set of unpredictable contextual conditions (weather or quality of the snow for example). How these contextual elements will cause variants to story generation is an open line of research to be followed.

In any of the issues mentioned above there is a need for a larger corpus. We are pursuing the data acquisition in order to record this 'parallel' corpus with to the best of our knowledge is currently non-existent in the community. Despite the limited outcome of this study, the findings could be beneficial for others fields. For instance, the ski touring domain is close to domain in which a predefined route and wearable devices can be used such as in rescue operation, city travel or tourism.

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A Character Model with Moral Emotions: Preliminary Evaluation

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Abstract

In literary and drama criticism, emotions, and moral emotions in particular, have been pointed out as one of characterizing features of stories. In this paper, we propose to model story characters as value-based emotional agents, who appraise their own and others' actions based on their desires and values, and feel the appropriate moral emotions in response to narrative situations that challenge their goals and values.

In order to validate the appropriateness of the agent model for narrative characters, we ran an experiment with human participants aimed at comparing their expectations about characters' emotions with the predictions of the value-based model of emotional agent. The results of the experiment show that the participants' expectations meet the predictions of the model.

1998 ACM Subject Classification I.2.11 Intelligent Agents, I.2.0 Cognitive Simulation

Keywords and phrases emotion models, virtual characters, moral emotions, empirical evaluation

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1 Introduction

Since the Age of Enlightenment [18], narratology and drama studies have acknowledged the importance of emotions in stories. In contemporary film theory and aesthetics, emotions play a central role because they sustain the process of identification with the characters. [22, 44, 11]. According to [28], "sympathetic responses to narrative characters", seen as mechanisms of emotional participation, are the most basic form of narrative engagement.

Notwithstanding this interest in characters' emotions, moral emotions have been scarcely considered in computational models of narrative. Literary and drama studies have acknowledged the importance of the moral dimension since the pioneering work of Polti [37]. The notion of moral values, first stated in Egri's definition of 'drama premise' [19], underpins most of the subsequent work conducted in scriptwriting [10], until the recent formulation stated by McKee [35] for cinematographic stories. In cognitive psychology, Bruner attributes to narratives the function of exemplifying and transmitting the values of a culture [8]. Research in interactive narrative has tackled the moral aspect of stories [47, 2], but it has addressed moral values from the perspective of plot generation, without considering their relevance for characters' emotions.

In this paper, we propose to adopt the value-based emotional agent described in [3, 4] to model narrative characters, and describe a preliminary experiment conducted to test the suitability of this model for narrative situations where moral values are put at stake. In

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this model, the agent's emotions are generated from the appraisal of how the contingent situation affects the agent's desires and values. The agent has an explicit representation of its moral dimension based on a value system [25], and a motivational dimension given by the desires it wants to pursue [7]. When choosing a course of action, the agent trades off its values against their desires, and relies on its moral values to evaluate its own behavior and the behavior of the others, feeling emotions like Reproach or Anger, or Gratification. For each narrative situation, the subjects were asked to act and feel according to the characters' beliefs and values, as if they were doing practice in an acting school. Then, we compared the actions and emotions they selected with the actions and the emotional states generated by the model, in order to gain insight on its validity and coverage.

The paper is organized as follows. After surveying the related work (Section 2), we describe the computational model of a character with moral values and emotions (Section 3) that we assess through the experiment. In Section 4 we describe the experiment design and the methodology by which the narrative scenarios employed in the experiment were developed. The description of the narrative scenarios is described in Section 5. In Section 6 we illustrate and discuss the results of the evaluation, making hypotheses about how the experiment design could be improved. Conclusions ends the paper.

2 Related Work

Many researchers tried to integrate computational models of emotions in a cognitive architecture for intelligent agents (of which [39, 21, 33] are some examples), with the aim of inserting emotions in BDI (Belief-Desire-Intention) agents [7]. Although different theories of emotions have been proposed (including physiological and dimensional models), most computational models are based on appraisal theory, in which cognitive processes are involved in the generation of emotions [36, 32, 41].

According to appraisal models, cognitive processes have the function of building a mental representation of the situation in which a person is involved (*person-environment relation*). This representation is not limited to the external environment, but also includes the internal disposition of a person, such as goals, desires, intentions, norms and moral standards. Emotions arise from the appraisal of the person-environment relation according to the appraisal dimensions that are defined by the theory (i. e. desirability of an event, praiseworthiness of an action).

According to the OCC model of emotions [36], *Joy* (*Distress*) emotion arises from being pleased (unpleased) about a desirable (undesirable) event. *Pride* (*Self-reproach*) emotion arises from the approval (disapproval) of one's own praiseworthy (blameworthy) action. *Admiration* (*Reproach*) emotion arises from the approval (disapproval) of someone's else praiseworthy (blameworthy) action. OCC model define also 'Compound emotion' *Gratification*, *Remorse*, *Gratitude* and *Anger*. Gratification (Remorse) emotion arises from Joy (Distress) and Pride (Shame), Gratitude (Anger) emotion arises from Joy (Distress) and Admiration (Reproach).

Moral emotions arise from evaluations in regard to moral principles [30, 36] and they have been argued to play a crucial role in decision making [26, 43, 31, 46, 14]. According to [26], moral sentiment serve as 'commitment devices' that lead agent to overcome selfish behaviors in favor of pro-social behaviors, which account for the compliance with social norms. The consequence for emotional characters is that they must balance their personal goals with their moral dimension for their behavior to be believable. Although encompassed in appraisal theories, most computational models [34] don't account for moral emotions (e. g. Pride, Shame) [30] but, mostly, focus on emotions related to the desirability/undesirability of situations with respect to goals, and don't account for moral values.

The EM system [39] integrates the OCC appraisal theory of emotions with a domain-independent approach, but the generation of moral emotions is based on the violation of goals such as *help my goals to succeed* or *do not cause my goals to fail*. ALMA [27] encoded the OCC theory with domain-dependent rules, thus failing to grasp general principles. The FLAME [20] architecture, based on OCC and Roseman appraisal theory [40], models emotions with fuzzy logic rules which map events and expectations onto emotional states (and behaviors). The system is not provided with the ability to independently assess the moral consequences of events and actions: instead, they are acquired through the user's feedback. In EMA [33], the first fully-implemented framework for conversational agents, appraisal is formed by a set of independent processes that operate on a plan-based representation of person-environment relation, named *causal interpretation*. This work is mainly based on Smith and Lazarus theory [32], where moral standards are not modeled. By lacking an explicit representation of moral dimension, the model fails to differentiate between different moral emotions (e. g. Shame from Remorse).

As argued by [23], emotional characters must balance their personal goals with their social environment in order to be believable. In the field of normative agents [12], a few works address moral emotions related to norm violation by casting norm violation as goal violation [29] or modeling norm violation in a domain specific way, thus lacking of flexibility [42, 9]. Regarding norms, one of the few exceptions to the trend of focusing on goal-related emotions is the work by Ferreira et al. [23]. In their work, they propose an agent model with an explicit representation of cultural and social norms, employed to check if actions violate or fulfill an activated norm. This appraisal process generate moral emotions such as Pride, Shame or even Anger (towards a target that violated a norm). Despite being able to generate moral emotions, this work focuses on the use of domain-specific cultural and social norms (e. g. not smoking in a bar) which are usually shared across a set of individuals. In our approach, we focus on the more generic concept of individual moral values, which can be easily adapted to new situations. Moreover, the work by [23] does not address the question of how to use the moral appraisals/emotions to guide decision-making.

The model we adopt in this work relies on the OCC model to establish an explicit link between moral values and moral emotions [4]. The agent is endowed with an explicit moral dimension formed by a scale of moral values (such as 'honesty', 'freedom') [25].

Basically, in the deliberation phase, the agent feels 'anticipatory' emotions, which allows it to envisage the consequences of its available options: the agent chooses the best option in the light of its *emotional reward*, i. e. the emotional states that each option would determine. Since the OCC model acknowledges a distinction between positive and negative emotional states, the agent will tend to prefer the lines of behavior that are more likely to make positive emotional states arise in it, avoiding ugly emotions [13] such as Shame or Remorse.

3 Values and emotions

Based on the work by [4], the character is modeled as a BDI agent [38] with a mental representation formed by beliefs, desires and moral values. Beliefs represent agent's knowledge about the world. Desires represent the agent's motivational component (i. e. what the agent desires to obtain), while moral values represent the character's moral dimension.

Inspired by [45], desires are associated with three different sets of conditions, namely *adopting conditions*, *success conditions* and *failure conditions*, which determine the adoption and achievement of desires. For example, when the agent believes that the adopting condition of a desire is verified in the world, the desire becomes an intention and can compete for being selected by the agent. If adopted, the agent tries to devise a sequence of actions to reach the desire. When the agent believes that the success (failure) condition of the desire is verified in the world, the corresponding intention is achieved (unachieved).

Values are moral and ethical principles [36] that the agent consider important (e. g. honesty, freedom, family). According to [25, 15], moral values are subjective, and different individuals acknowledge different values arranged into subjective 'scales of values' (each agent's value is associated with a numeric priority). The set of values owned by the agent contributes to drive the behavior of the agent. Moral values are the moral drive of the agent, they constrain the behavior of the agent to its moral dimension and allow the agent to appraise the behavior of other characters. Every value is associated with a set of *violation conditions* that represent the states in which the value is at stake, i. e. something is happened in the world that makes the moral value violated.

In order to display a believable behavior, the agent's drive cannot be limited to its motivational component: the agent has to show that a moral dimension drives its behavior. According to [4], when the agent translates its goals into practical lines of behavior, the projection of these lines of behavior must also encompass the evaluation of the agent's own emotional states, such as Shame or Pride, that contribute to orientate the agent's choice towards value-compliant courses of actions (*anticipatory emotional appraisal*). The advantage of this integration is that the agent not only forms its goals based on the compliance with its values, but moral emotions become relevant when conflicting goals (and plans) are formed and must be traded off against the compliance with values.

Following [36], the *Appraisal Derivation* process evaluates the agent's mental representation of the world based on its goals and values, and outputs a set of appraisal variables. The *Affect Derivation* process determines what emotions arise from the appraisal variables according to the reference theory of emotions. The appraisal of events as desirable or undesirable depends on the processing of goals. A *desirability* (*undesirability*) variable is generated when a goal is achieved (unachieved) in the state of the world. The appraisal of actions is based on the processing of values: when a value is balanced (put at stake) in the current state of the world, the appraisal derivation model generates a *praiseworthiness* (*blameworthiness*) variable. Given the appraisal variables, the Affect Derivation Model generates emotions according to the following domain- independent rules (Figure 1).

- **Joy** if the appraisal variable *desirability* is generated (i. e. a goal is achieved);
- **Distress** if the appraisal variable *undesirability* is generated (i. e. a goal is unachieved);
- **Pride** and **Admiration** if the appraisal variable *praiseworthiness* is generated (i. e. an action re-balances a value at stake);
- **Shame** and **Reproach** if the appraisal variable *blameworthiness* is generated (i. e. an action puts a value at stake).

Following [36], when both appraisal variable regarding actions and goals are generated, the Affect Derivation Model generates the following compound emotions: **Gratification** (Joy and Pride), **Gratitude** (Joy and Admiration), **Remorse** (Distress and Self-Reproach), **Anger** (Distress and Reproach). The intensity of goal-related emotions is based on the importance of success and failure of goals multiplied by the effort made (i. e. the cost of the plan executed), while the intensity of value-related emotions derives from the importance of values.[1]

[1] The reader can refer to [17] for a complete example of how emotions intensity can be calculated.

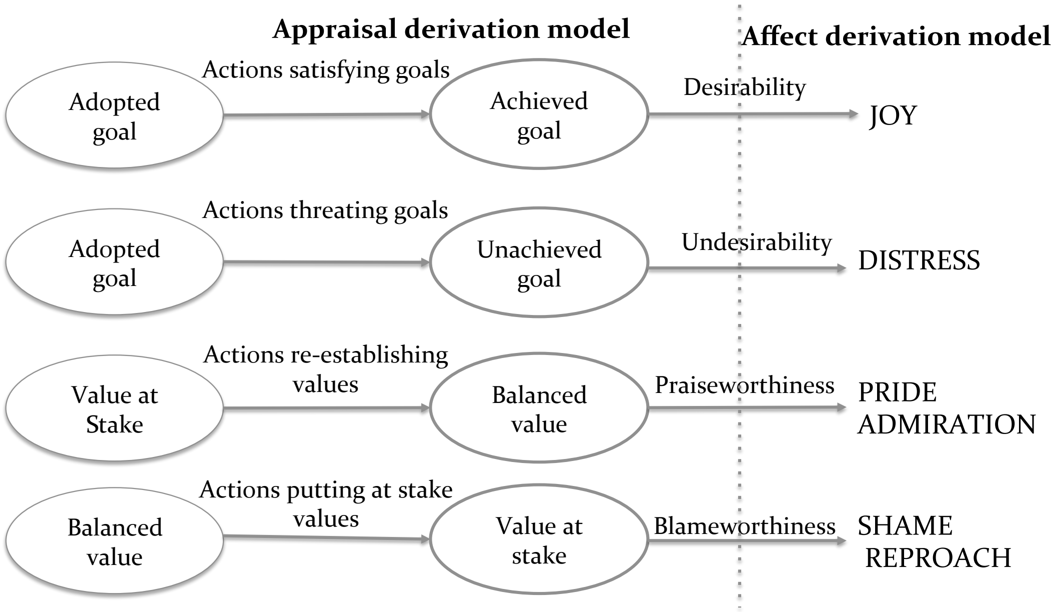

Figure 1 Appraisal and Affect Derivation model in [4].

In [4], emotional appraisal play a role also the agent's deliberation, i. e., the agent chooses a line of behavior in the light of the emotional states it would determine (emotional reward). Since the OCC model acknowledges a distinction between positive and negative emotional states, the agent will tend to prefer the lines of behavior that are more likely to make positive emotional states arise. The emotional reward derives from: (1) the intensity of the joy that the agent feels if it reaches an individual goal through a plan π (2) the distress intensity that the agent feels if, executing the plan π, some other adopted goals π has become unachievable; (3) the pride intensity that the agent feels if it re-establishes a value at stake through the plan and reaches the related moral goal; (4) the self-reproach intensity that the agent feels if the plan π threatens some other values. Given a plan π , we noted with G_A the set of individual goal satisfied by the plan, with G_T the set of individual goals threatened, with V_B the set of values re-established and with V_T the set of values put at stake. The intensity of anticipatory emotions **Joy** $EER_J(G_A, \pi_i)$, **Distress** $EER_D(G_T, \pi_i)$, **Pride** $EER_P(V_B, \pi_i)$ and **Shame** $EER_S(V_T, \pi_i)$ are:

$$EER_J(G_A, \pi_i) = \frac{P(\pi_i) * \sum_{g_a \in G_A} ImpOfS(g_a)}{E(\pi_i)} \tag{1}$$

$$EER_D(G_T, \pi_i) = \frac{P(\pi_i) * \sum_{g_t \in G_T} ImpOfF(g_t)}{E(\pi_i)} \tag{2}$$

$$EER_P(V_B, \pi_i) = \frac{P(\pi_i) * \sum_{v_b \in V_B} (r(v_b) + d(v_b))}{E(\pi_i)} \tag{3}$$

$$EER_S(V_T, \pi_i) = \frac{P(\pi_i) * \sum_{t_t \in V_T} (r(v_t) + d(v_t))}{E(\pi_i)} \tag{4}$$

where $P(\pi_i)$ is the plan probability of success, *impOfS* and *impOfF* are the importance of success and failure of the goal, $E(\pi_i)$ is the cost of the plan, $r(v_b)$ is the priority of the value and $d(v_b)$ is the degree with which the value is shared with the society. The models assumes a partial-ordering continuous planner extended with emotions like [1], in which operators are specified in an extended STRIPS-like notation [24]. Differently from a classical STRIPS operator where preconditions identify the set of states in which the action can be executed, and effects describes how the environment changes as a result of taking the action [24], an extended STRIPS-like operator associates stochastic effects to actions [6], so that the probability that a plan reaches a goal state can be calculated. The planner monitors all events in the world in order to detect when an action is accomplished or fails, updates all the plans and the probability of action effects according to the event perceived. The function $E(\pi_i)$ is calculated on the basis of the cost associated to the actions; the simplest case is the unitary cost, i. e. the cost of the plan is equal to number of actions presented in the plan. The other quantities used in the formulas given above, such as the priority of the value $r(v_b)$ for example, are specified at design time. Finally, given the emotional reward, the overall plan utility is computed as:

$$EER = (EER_J + EER_P) - (EER_S + EER_D) \quad (5)$$

For example, consider the following situation. Boo has the goal to eat a chocolate candy; in order to satisfy her goal, the chocolate candy must be stolen from Mary, but the *steal* action makes the violation condition of the value *honesty* true. So, if Boo executes her plan, the emotional reward utility will derive from the combined intensity of Joy and Shame. Let us consider another plan, in which Boo asks Mary to give her the chocolate candy. In this case no value is put at stake and the emotional reward utility will derive from the Joy intensity only. If the value *honesty* is very important for Boo, she chooses the plan to ask Mary the chocolate candy, even if the plan has a lower probability of success.

Note that, if the alternative plans have the same emotional reward utility, the characters is in a dilemma. In [3] the model is employed to deal with faces a moral dilemma.

4 Experiment design

In order to test the suitability of the value-based model of emotions described in [4] for modeling the behavior of narrative characters, we performed a preliminary evaluation on narrative scenarios with human subjects. The experiment we designed relies on a direct comparison between the predictions of the model about the characters' emotions and actions and the expectations of the human subjects about them. In order to evaluate if the model correctly predicts how a character's behavior and emotions are affected by its moral values, we compared the emotions and actions generated by the model with the emotions and actions that human subjects expected from the character.

The experiment was conducted online, via a text-based web interface (Figure 2).[2] For each scenario, a short text introduced the character and her/his values, then a narrative situation was described that put a stake the character's values. The scale of values was presented to participant not in a numerical format but with a figurative scale, in order to make the values priorities apparent at first glance. The task of identifying the expected course of action and emotions for the character was introduced to the participants as a game:

[2] The website of the experiment can be found at `http://www.ilnomedellarosa.it/ActorStudio` (in Italian only).

Figure 2 The first page of the experiment website, in which the narrative scenario (a narrative situation and the main character's scale of values) is presented to a user.

the participants were asked to pretend they were exercising identification in an acting class, in order to leverage their capability to take the point of view of the character and behave "as if" they were the in the character's shoes. For each scenario, a pair of alternative actions were submitted to the participants, who also had to select a set of appropriate accompanying emotions.

The narrative situations included in the experiment were created by a story editor by taking inspiration from literary stories. By doing so, we wanted to reduce the arbitrariness of the relation between, on the side, the characters' goals and values, and, on the other side, their actions and emotions. Each narrative situation (story world, story incidents and participants) was encoded in formal terms as described in Section 5 and the value-based emotional model to be tested was employed to generate the behavior of the main character. The resulting behavior and emotions were submitted to the story editor to verify that they were consistent with the original story.

The goal of the experiment was twofold: first, we wanted to assess the role of values in action selection, i. e. if, given a scale of values and a narrative situation, the course of action selected by the participants matched the course of action generated by the model (Question 1); second, since the model postulates that emotions mediate (through the notion of anticipatory appraisal, see Section 3) the role of values in action selection, we wanted to assess if the emotions that participants attributed to characters matched the emotions generated by the model (Question 2).

After going though three scenarios, participants were given a post questionnaire in which we asked information about their age, sex, etc. Moreover, for each value oppositions involved in the scenarios, we asked them to indicate what value they preferred (i. e. "What is more important according to you, honesty or loyalty?"). By doing so, we wanted to measure the degree to which the choice of actions and emotions made by the participants was reliable, i. e., if it was affected by their own scale of values instead of being driven only by the identification process.

Scenario	Question	Action	Values
One Wallace and uncle George's roses	What would you do instead of Wallace, given his scale of values?	Refuse to give the key to Charlie	Honesty
		Give the key to Charlie	Loyalty to Charlie
Two At school!	What would you do instead of Tom, given his scale of values?	Umiliate Pier, taking revenge on him	Justice
		Let it go	Pity
Three A difficult choice	What would you do instead of Mark, given his scale of values?	Stay in New York	Happiness
		Go to Italy and stay with the family	Family

Figure 3 Available actions for each scenario (see descriptions in Section 5).

In order to promote the participants' identification with the characters, after each task the web based system attributed them a score based on their "performance" (i. e., the coincidence of the selected actions and emotions given the ones predicted by the model).

Measures: In Figure 3 we illustrate the pairs of actions that are opposed in each scenario. A detailed description is provided in Section 5.

For emotions, we adopted the emotions categories encompassed by the OCC theory of emotions [36] (see Section 3). We described the emotions to the participants by specifying, for each emotions, the target of the emotion and its appraisal dimension (e. g. "Pride arises from an appraisal of somebody's action as praiseworthy").

In the post questionnaire, we asked participants general information, i. e., if the scenarios were difficult to read and to understand, and what value they prefer between the values in conflict of each scenario (e. g. e. g., Honesty and Loyalty). Summarizing, from the experiment execution, we get actions and emotions selected by users, and a short text describing motivations of their choices; from the post-questionnaire, we get the preference values for each value opposition, and an evaluation of the clarity and readability of the scenarios.

Participants. A convenience sample of 42 Italian subjects, 18 female and 24 male, aged 23-65, participated in the experiment. Participants had high levels of computer literacy (60% described themselves as being expert), they had previously interacted with virtual characters and usually played video-game (40% declared having interaction with virtual character at least one day a week, 45% declared playing video-games at least three days a week).

Experimental Protocol. The participants played the first scenario. First, they read the summary of the narrative situation; then they chose the action and the emotions for the main character. After the participant made his/her choice, the system showed the emotions and actions generated by the value–based emotional agent model. The same for the second and the third scenario. For each scenario, we asked the participants to describe the motivations underlying their choices, in order to perform a qualitative analysis on them. After running the three scenarios, participant answered to the post questionnaire.

5 Narrative scenario examples

The narrative scenarios designed for the experiments are characterized by a conflict of goals and values. Created with the help of a drama expert, they are inspired by well known literary works. The agent model described in Section 3 was employed to model the behavior of a character in each narrative situation. The model was implemented into FAtiMa [16], a modular architecture designed to develop emotional agents. For each scenario, two lines of behavior were generated by altering the value priority, but only one matched the actual character's behavior in the narrative situation that inspired the scenario. Note that, being a preliminary evaluation, we simplified the anticipatory emotional appraisal by modeling scenarios with plans formed by only one action (i. e. with an unitary cost) and we assumed that plans have a success probability of 1.0 (in other words, that they cannot fail).

The first scenario, 'Wallace and uncle George's roses', is inspired by the 'nunnery scene' in Shakespeare's Hamlet [5], where one of the drama main characters, Ophelia, has to decide whether to lie to the protagonist, Hamlet, thus putting at stake the value 'Honesty', or to reveal the truth, thus putting at stake the 'Loyalty' towards her father.

The second scenario and third scenario, 'At school' and 'A difficult choice', were inspired by the thirty-six dramatic situations described in Polti's work [37]. From a large repository of plays, Polti extracts a list of situations that are perceived as intrinsically dramatic. Each situation is named after a specific action (e. g. Vengeance). Within each situation, Polti defines: the kind of agents (e. g. victim, culprit), the beliefs and goals that motivate the action (e. g. the agents' cognitive states) and the emotions felt by agents, then lists a set of literary examples.

In particular, 'At school' is based on the third situation 'Crime pursued by vengeance' in which Polti argues that vengeance is a divine Joy felt by those who pursue it after being victim of a crime with no guilt. "A difficult choice" is based on the thirty-fourth situation 'Remorse' in which the culprit feels Remorse for something she/he committed. The choice of modeling scenarios inspired by well known narrative situations, instead of employing literary stories, resides in the motivation that participants may know the literary stories and what the characters do in them, thus negatively affecting the experimental methodology.

5.1 Scenario one, Wallace and uncle George's roses

Summary: Wallace and Charlie are cousins. They live in the country where uncle George has a nursery of precious roses he brings to gardening contests. Uncle George is very jealous of his roses. Charlie wants to make a gift to his girlfriend and asks Wallace to give him the key of the nursery to get one. Wallace knows where the key is but he also knows that uncle George does not want anyone to enter.

In this scenario, Wallace has to choose whether to be loyal with his cousin Charlie or to uncle George (Figure 4). Wallace owns the value 'Honesty' with 7.0 priority and the value 'Loyalty to Charlie' with 8.5 priority. During his reasoning cycle, the system (in the role of Wallace) finds two plans: the plan $p1$ contains the action of giving the key to Charlie, thus deceiving uncle George; the plan $p2$ contains the action of refusing to give the key to Charlie. The plan $p1$ puts at stake the value 'Honesty' (Figure 4): if Wallace executes this plan he will feel Shame emotion for putting at stake this value.

On the other hand, the plan $p2$ puts at stake the value 'Loyalty' (Figure 4). If Wallace executes this plan, he will feel Shame emotion for putting at stake this value. Wallace is in a dilemma. Assuming that the two plans have the same probability of success, Wallace's anticipatory appraisal leads him to choose the plan with the highest *EER*: in any case,

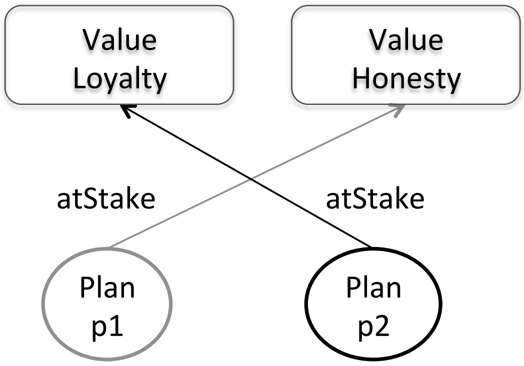

Figure 4 Scenario 1 (Wallace): the plan $p1$ puts at stake the value 'Honesty', while the plan $p2$ the value 'Loyalty'.

Wallace will feel Shame, but the anticipatory appraisal leads him to choose the course of actions that brings him to a state in which the Shame intensity is lower. Wallace executes the plan $p1$: he gives the key to Charlie and feels Shame for putting at stake the value 'Honesty'.

5.2 Scenario two, At school!

Summary: Tom is bullied by his classmate Pier. Pier has taken from Tom the role of director of the school newspaper, putting around lies about him. The result is that Tom lost the director position and he is now in a bad light. A few days later, Tom sees that Pier has forgotten his backpack with all his stuff in the locker room. Tom digs in Pier's backpack and finds evidence that Pier copied the class test. Tom is now uncertain about what to do, whether to take revenge against Pier or to pass through this situation.
In this scenario, Tom has to choose if he wants to take vengeance or not, Figure 5). Tom owns the value 'Justice' with 8.5 priority and the value 'Pity' with 7.5 priority. During his reasoning cycle, Tom finds two plans: the plan $p1$ contains the action of humiliating Pier; the plan $p2$ contains the action of letting it go. The plan $p1$ puts at stake the value 'Pity' (Figure 5): if Tom executes this plan, he will feel Shame for putting at stake this value. But the plan $p1$ also brings back to balance the value 'Justice', put at stake by Pier, and satisfies the goal of being the director again. In addition to Shame, Tom will feel Joy for satisfying his goal and Pride for restoring his value 'Justice'. The activation of these emotions at the same time gives the compound emotion Gratification.
On the other hand, the plan $p2$ has no effects (Figure 5). If Tom performs this plan, the situation doesn't change and the value 'Pity' is not put at stake. Note that, according to our model, in the past Tom felt Anger toward Pier for being mean to him (Pier put at stake one of Tom's values thus generating a Reproach emotion in Tom and made his goal of being a director unachievable, thus generating an emotion of Distress). In this case, these emotions will continue to decay and Tom won't feel any new emotions.

Assuming that the two plans have the same probability of success, Tom's anticipatory appraisal component chooses to execute the plan of taking revenge on Pier: Tom will feel Shame for putting at stake the value 'Pity', but the anticipatory appraisal chooses the course of actions that brings Tom in a state of affairs in which the overall emotion intensity is the highest. So, Tom executes the plan $p1$, he takes revenge, satisfies his goal, restores his value 'Justice' and puts at stake the value 'Pity'. Thus, Tom feels Shame and Gratification emotion (Joy and Pride).

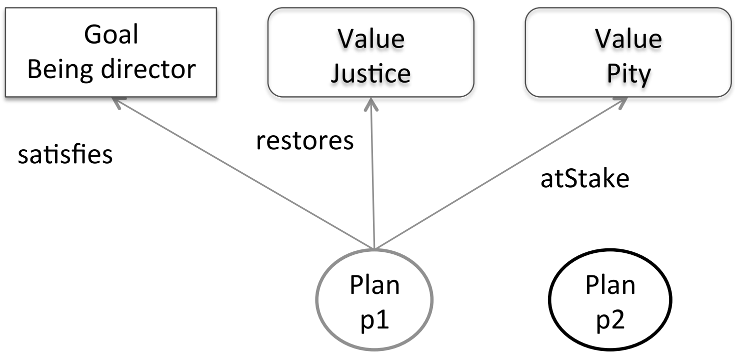

Figure 5 Scenario 2: Tom's plan $p1$ satisfies the goal and value 'Justice' but puts at stake the value 'Pity'. Plan $p2$ has no such effects on values and goals.

5.3 Scenario three, A difficult choice

Summary: New York, 2003. Mark and Lucy are married and they have a beautiful baby. Lucy has agreed to go a couple of years in Italy for the job of her dreams: working as a curator of a famous art gallery in Rome. Mark, however, has always wanted to be judge in New York. Just when Lucy has officially accepted her job in Italy, Mark gets the seat as a judge in New York. Mark's desires are of being with his family and having the work of his dreams as well. Now, he has to choose whether to have the job or to stay with his family.

Mark (Figure 6, Figure 7) owns the value 'Family' with 8.0 priority and the value 'Happiness' with 8.5 priority. The goal of being with his family has an importance of success equals to 8.0, while the goal of being a judge has an importance of success of 8.5. During his reasoning cycle, Mark finds two plans: the plan $p1$ contains the action of staying in New York without his family; the plan $p2$ contains the action of going to Italy. The plan $p1$ puts at stake the value 'Family', threatens the goal of being with the family and satisfies the goal of being a judge (Figure 7): if Mark executes this plan he will feel Shame for putting at stake a value, Distress for threatening the goal of being with the family, but Joy for satisfying his goal of being a judge. According to our model, Mark feels a Remorse emotion, since he feels a Shame emotion and a Distress emotion at the same time.

On the other hand, the plan $p2$ puts at stake the value 'Happiness', threatens his goal of being a judge and satisfies the goal of being with the family (Figure 7). If Mark executes this plan he will feel Shame for putting at stake the 'Happiness' value, Distress for threatening his goal of being a judge, but Joy for satisfying his goal of being with the family. In this case, Mark feels a Remorse emotion because he feels a Shame emotion and a Distress emotion at the same time.

Assuming that the two plans have the same probability of success, Mark's anticipatory appraisal component would choose to execute the plan that puts at stake the value with a lower priority ('Family'), due to the equal importance of success of both goals: in any case Mark will feel Shame, but the anticipatory appraisal would make him choose the course of actions that brings him in a state of affairs in which the Remorse intensity is lower. This scenario is very similar to the first scenario, because the two courses of actions that the character can choose bring the character to feel the same emotion, although for different reasons and with different intensity.

Character	Goals	Values	PLAN	EER	Emotions
Mark	Being judge(importance 8.0) Success conditions: <I'm a judge> Failure conditions: <...,go to Italy,...>	Happiness (priority 8.5) Violation conditions: <...,give up dreams, ...>	P1: <stay New York>	P1 effects: at stake Family Satisfied goal being judge	Joy Distress Shame Remorse
	Being with my family (imp. Of Success 8.0) Success conditions: <I'm with my family> Failure conditions: <...,stay in New York,...>	Family (priority 7.0) Violation conditions: <...,abandoning family, ... >	P2: <go to Italy>	P2 effects: at stake Happiness Satisfied goal being with famiy	Joy Distress Shame Remorse

Figure 6 Representation of Mark's goals, values and plans. For each value, the violation condition is specified that would hold in the state of the world which obtains if Wallace executes the action that puts at stake that value. In the EER column, we specify the action effects by taking into account in the generation of the Expected Emotional Reward utility for the action. We assume a unitary cost and same probability in the EER calculation in order to simplify the experiment.

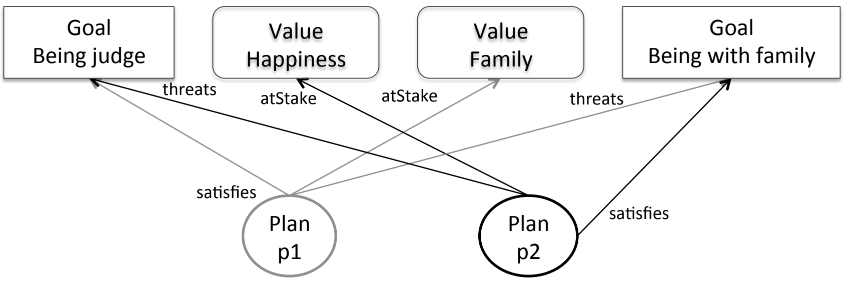

Figure 7 Scenario 3: Mark's plan $p1$ makes the goal of being a judge achieved, but puts at stake the value 'Family' and makes unachieved the goal of staying with the family. Plan $p2$ makes the goal of staying with the family achieved, but puts at stake the value 'Happiness' and causes the goal of being a judge to fail.

6 Results & Discussion

Given the narrative scenarios described in the Section 5, we run the experiment described in the Section 4 and compared the actions and emotions chosen by the human participants with the actions and emotions generated by the value-based emotional agent. In the following, we refer to the action that the computational model chooses in each scenario with the term 'right action' while, with the term 'wrong action', we refer to the action that the model doesn't choose to perform. Notice that this labeling is adopted only to simplify the description of the results: the 'right' behavior is the one that matches the actual behavior of the character in the narrative situation that inspired the scenario, but no choice can be defined as right or wrong because the scale of values and the relation between values and actions are intrinsically subjective [25].

Quantitative results. In order to assess if there is a correlation between the effectiveness of the identification process by the subjects and their inclination to feel certain emotions, we run a non parametric test (Mann-Whitney test) on the results of each scenario, dividing the group between the subjects who chose the right action and those who didn't, and related

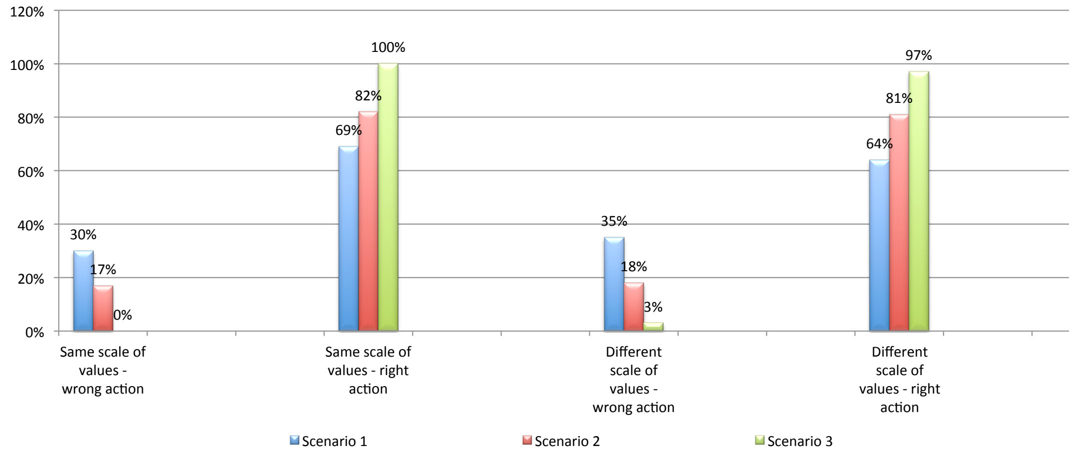

Figure 8 Frequencies on users choices about actions in each scenarios based on the same scale of values and on the different scale of values.

them with the selected emotions. In the first scenario, we found evidence that there is a significant difference (U= 71, n_1= 13, n_2 = 29, p one tailed < 0.01) between the subjects who selected the Pride emotion by choosing the wrong action and the subject who selected the Pride emotion by choosing the right action. Subjects who chose the wrong action are more inclined to feel a Pride emotion. We found no other statistical evidence in other scenarios. In order to assess if a different individual scale of values may have affected the identification process, we run a Mann-Whitney test specific to each scenario, dividing the group between the subjects who have the same scale of values of the characters and the subject who haven't the same scale of values as the characters. We found no significant evidence about selected actions by users with the same scale of values of the character and with the different scale of values. This result is in line with the theories of narrative engagement [28].

Qualitative results. The most part of the subjects asserted that the narrative scenarios were clear (81%), they had no difficulties in identifying with the characters (72%).

The actions chosen by the character model (the 'right' ones) were chosen also by the large majority of the subjects (81%), so the answer to Question 1 (Section 4, if given a scale of values and a narrative situation, the course of action selected by the participants matched the course of action generated by the model) was positive. Results show that the subjects started to understand the mechanism of the game as they proceeded through the tasks, so a larger group chose the right action in the second and third scenario than in the first scenario. As showed by the Mann-Whitney test, both subjects with the same scale of values as the characters and those with a different scale of values mainly chose the action predicted by our model (Figure 8). For example, in the first scenario, most participants with the same scale of values as Wallace (38%) selected the action predicted by our model (69%); however, most participants with a different scale of values selected the action predicted by our model as well (64%). These results show that subjects understand the mechanism of the game, and that the participants didn't have difficulties in identifying with the characters and to reason with their scale of values. The results also show that the participants substantially agreed with the prediction of our model, for both the action selection (determined by the anticipatory appraisal component) and the emotion generation (determined by the emotion appraisal model).

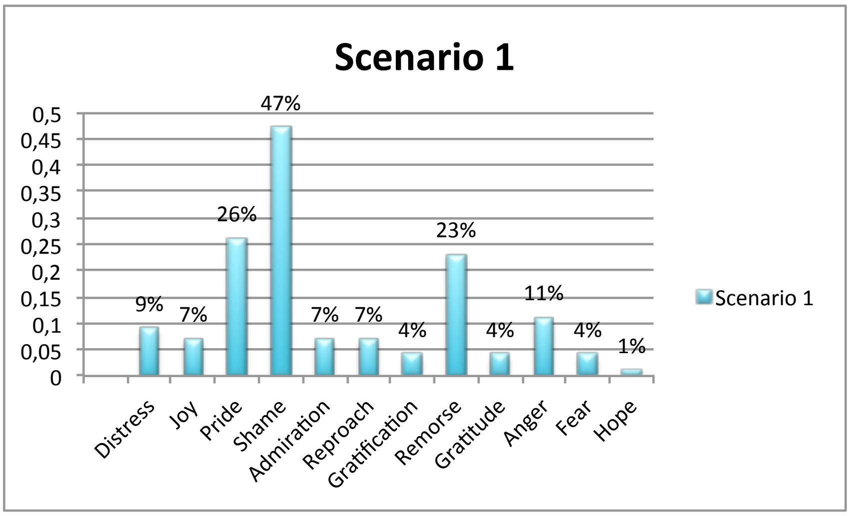

Figure 9 Frequencies of emotions chosen by the participants in the first scenario (we don't distinguish about subjects choosing the right or wrong action because the appraisal of emotions is identical).

Regarding the emotions selected in each scenario, the results show that the subjects agreed with the emotions generated by the value based emotional character (Question 2, Section 4, if the emotions that participants attributed to characters matched the emotions generated by the model).

In the first scenario, the subjects selected the Shame emotion (47%) and the Remorse emotion (23%)(Figure 9). They selected also Pride emotion (26%), that the character model does not generate in the context of the first scenario. Examining the motivations given by participants, we argue that people perceive the preservation of a value as a motivation for feeling Pride, a fact that is reasonable, although not covered by the current character model:

- pride for having acted in the right way (subject chose the wrong action, subject preferred 'Honesty');
- pride for helping a friend (subject chose the right action, subject preferred 'Honesty');
- pride for being loyal to my uncle (subject chose the wrong action, subject preferred 'Loyalty').

Subjects (23%) selected also Remorse emotion, with the motivations that 'I'm doing something that I don't want to do':

- remorse for doing something wrong (subject chose right action, subject prefers 'Honesty);
- remorse for betraying my uncle (subject chose right action, subject prefers 'Honesty');

Following OCC model, the character model generated Remorse only when the failure of a goal was involved in the appraisal. Results suggest us that the participants associated a sort of high-level goal (e. g. 'don't violate my standards' when the values in conflict both have a high priority).

In the second scenario, the participants selected the emotions predicted by our model (Joy 21%, Pride 26%, Gratification 27%). The participants selected also the emotions felt by Tom towards Pier (Anger 15%, Reproach 25% but not Distress 7%) (Figure 10). This is in line with the character model: Pier performed a blameworthy action against Tom (Reproach), making his goal of being a director no more achievable (Distress and, consequently, Anger).

In the third scenario, the emotions selected by the participants agree with the emotions generated by to the character model (Distress 31%, Joy 45%, Shame 26%, Remorse 23%)

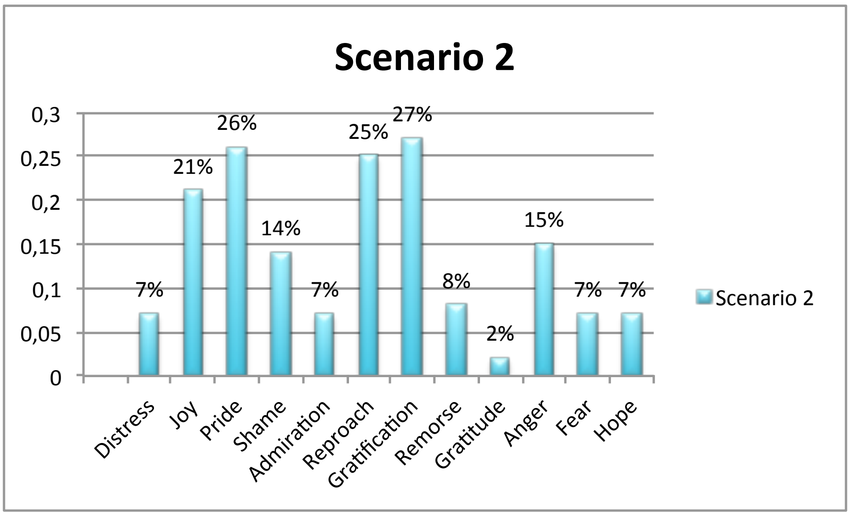

Figure 10 Frequencies of the emotions chosen by the participants in the second scenario (only the participants that made the right decision).

(Figure 11). Fear and Hope emotions were selected by the most part of participants. Examining the motivations they provided, we found that the fear was the "fear of the future" and "hope in a better future".

- hope in the future, maybe I can gather the family again in the future (participant chose right action);
- fear for the future, my family may have problems without me (participant chose right action).

Discussion. The results suggest that our model is congruent with partipants' choices. We need to study into depth the difference that the experimental subjects find between putting at stake a value and safeguarding a value from being put at stake. The results suggest that the emotions related with the praiseworthiness of actions can arise when a value is preserved from being put at stake. However, in order to obtain more reliable results, the narrative scenarios should be provided to the participants in random order. Even if no significant difference was found among the results obtained in the three scenarios, the qualitative observations suggest that the participants may have tuned to the experiment setting across the scenarios.

The motivations expressed by the participants for their choices suggest relevant improvements to the emotional agent model. The model can be extended it to grasp the difference between the situation in which a value at stake is re-established and the situation in which a value in balance – but threatened! – is preserved. Summarizing, the results are encouraging for the character model: the Anticipatory Emotional Appraisal seems to be acknowledged by the most part of participants and the emotions generated seem to be congruent with the emotional agent model employed in the experiments, and with the relations with goals and values predicted by this model.

We consider the results of our experiment promising, and we plan to run a more complex experiment in which we can assess other aspects of the emotional agent model, including the evaluation of cost and probability of plans, in order to get a complete evaluation of the anticipatory appraisal formulas. In a more complex evaluation, for each scenario, a group of participant should be given a choice of actions that include an action associated to a 'noise' value, so that a comparison may be conducted between the participants who evaluate

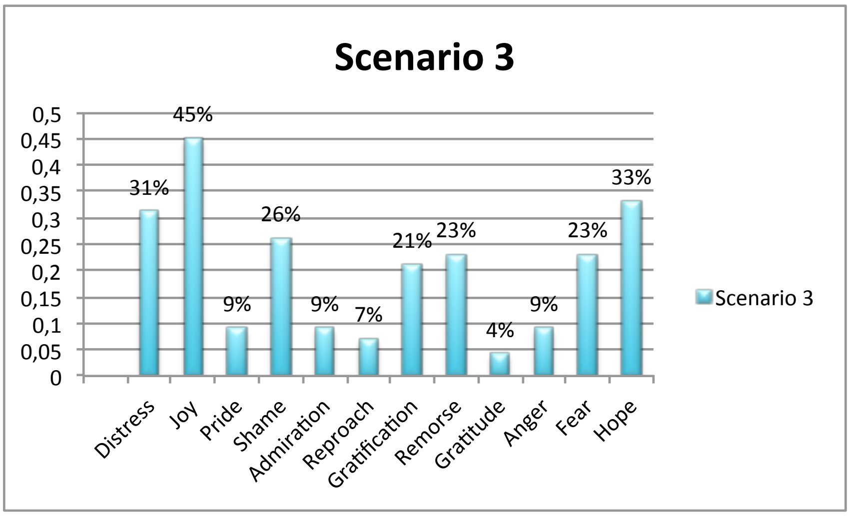

Figure 11 Frequencies of the emotions chosen by the participants in the third scenario (we don't distinguish about users choosing right or wrong action because the appraisal of emotions is identical).

the standard scenario and the participants that evaluate the scenario with the 'noise' value. Another experiment is to test if, given the action chosen by a character, the participants associate it with the value encoded in the computational model, in order to assess (or learn) the action-value associations.

7 Conclusion

In this paper, we describe an experiment devised to validate the appropriateness of a value based emotional agent model for modeling narrative characters. The experiment compared the expectations of human subjects about characters' behavior and emotions with the predictions of the agent model. The results of the experiment show that the users' expectations meet the predictions of the model.

The results also provide important insights on the relation between values and emotions, that we will address in the future work. The character model can be improved by extending it to grasp the difference between the situation in which a value at stake is re-established and the situation in which a value in balance – but threatened! – is preserved. Also, we need to study in depth how the difference between Remorse and Shame emotions is perceived by the audience in narrative situations.

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Towards Empathic Neurofeedback for Interactive Storytelling*

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Abstract

Interactive Narrative is a form of digital entertainment based on AI techniques which support narrative generation and user interaction. Despite recent progress in the field, there is still a lack of unified models integrating narrative generation, user response and interaction. This paper addresses this issue by revisiting existing Interactive Narrative paradigms, granting explicit status to users' disposition towards story characters. We introduce a novel Brain-Computer Interface (BCI) design, which attempts to capture empathy for the main character in a way that is compatible with filmic theories of emotion. Results from two experimental studies with a fully-implemented system demonstrate the effectiveness of a neurofeedback-based approach, showing that subjects can successfully modulate their emotional support for a character who is confronted with challenging situations. A preliminary fMRI analysis also shows activation during user interaction, in regions of the brain associated with emotional control.

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1 Introduction

One of the major challenges for Interactive Narrative technologies is to improve the conceptual integration between their various components: narrative generation, user interaction and user experience. After a decade spent developing Interactive Narrative prototypes, it appears to us that such an integration is more than a theoretical endeavour, and would also

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benefit the engineering aspects of the discipline. One promising direction is to take advantage of recent developments in affective computing to unify user interaction and the narrative experience. In previous work [9], we have investigated the use of peripheral physiological signals (galvanic skin response (GSR) and facial electromyography (EMG)) as a continuous input modality to an Interactive Narrative. This approach has been implemented in a prototype in which passive signals captured from the user drove the evolution of a real-time narrative with a duration of up to 8min. However, in addition to the imperfect correlation between peripheral physiological signals and affective dimensions, the conceptual integration between the affective computing model, the user response, and the filmic strategy adopted by the narrative generation process still left room for improvement.

Recent research in media psychology has emphasised the central role of characters in both the affective response of users and the overall entertainment experience [8, 30]. This suggests that direct interventions on the bond between user and character could not only provide a powerful interaction mechanism, but one that would be better aligned with the user response. This bond between users and story characters has generally been characterised as *empathy* [30], despite different interpretations of the concept.

We were thus in search of a physiological mechanism that could more directly relate to empathy, attachment or disposition, and that would also be accessible to real-time measurement, so as to be usable as an input mechanism. Numerous studies correlating affective responses with EEG signals in the alpha band (8–12Hz), have led to the development of a prefrontal asymmetry metric [13] to characterise modulation of affective response [5, 6]. Some of these studies have included the use of short films to induce emotion [35], making this approach even more relevant to us. Frontal asymmetry is considered a marker of approach/withdrawal [6], which is a high-level affective dimension independent from valence. Several authors have established a connection between alpha asymmetry and positive thinking [2], as well as empathy [32]. More specifically, Light et al. [16] have related an increase of frontal alpha asymmetry (indicative of approach) to empathic cheerfulness, which consists of a positive response towards an agent which is perceived to be in distress.

This has led us to consider alpha frontal asymmetry as a measure of disposition towards story characters which could serve as a basis for user input, provided it could be captured in real-time as part of an Interactive Narrative. This was suggested by the finding that frontal asymmetry can be controlled through Neurofeedback (NF) using EEG signals [27]. Although most applications of frontal asymmetry NF have been developed in the clinical domain, it has also been identified as a potential BCI technology [4]. Furthermore, a NF approach is well suited to an Interactive Storytelling application, since its voluntary nature is adapted to user intervention, and feedback mechanisms can be embedded into the visual presentation of the narrative itself.

In this paper, we lay the foundations for a unified approach which brings together an affective filmic theory (Tan's character empathy [30]), a character-based narrative generation technique [22], and a BCI mechanism compatible with empathy (pre-frontal alpha wave asymmetry as proposed by Henriques and Davidson [13]). We have created a baseline Interactive Narrative based on a medical drama (an extension of the narrative presented in [9]), which features a junior female doctor facing all sorts of challenges in her work, personal and professional ones. The story would spontaneously evolve towards the character's demise, in the absence of successful user intervention through the BCI. In the next sections, after reviewing related work, we introduce our BCI-based interactive storytelling system, which operates inside an MRI scanner so that explorations can be conducted using functional MRI (fMRI). We then describe the planning techniques used in narrative generation, how they control the level of difficulty faced by the feature character, and how they respond to user empathic support. After a presentation of the BCI implementation (frontal alpha asymmetry), we discuss results from our first proof-of-concept experiments which include fMRI results. We then report a larger-scale usability experiment, outside the MRI scanner, which takes advantage of the above results to refine the implementation of the BCI technique. We conclude by analysing subjects performance and identifying directions for further improvements.

2 Previous and Related Work

There has been previous interest in the neuroscience of film and computer games, some of which has informed the design of BCI systems. Morrison and Ziemke [36] have studied empathy towards characters in computer games from a neuroscience perspective. Recent work in neuroimaging has provided evidence for specific activation pathways that correspond to a range of empathic responses when viewing films with high emotional content [25], and Tikka et al. [31] have proposed a similar approach using BCI, while not reporting an implementation of their system. BCIs have, from their inception, been used in conjunction with interactive media (i.e. video games), mostly from the perspective of an interface technology either in an entertainment setting [19] or in a therapeutic one, with little exploration of the relationship to the media content itself. A critical analysis of the performance of existing BCIs [17] has led to both the emphasis on user training and the increasing relevance of NF as an implementation paradigm. This was demonstrated in a commercially available game environment in AlphaWoW [21], which used a version of *World of Warcraft*. However, this only went as far as addressing a single control variable (switching between two character forms) with a relaxation-based BCI using alpha waves. The development of BCIs for computer games has been recently reviewed by Marshall et al. [18]. In conjunction with game environments, NF has also been used for ADHD therapy. More specifically, frontal asymmetry has been identified as an element of a model of intrinsic affect evident while playing games [26].

3 System Overview

We have developed ENFASIS (Empathic Narrative using Frontal ASymmetry for Interactive Storytelling), a fully implemented system based on our proposed BCI approach and configured for proof-of-concept experiments using simultaneous fMRI analysis. The overall architecture of the system is shown on Figure 1: narrative actions are generated using constraint-based planning [9] and are visualised as real-time animations within the Unreal® 3D game engine (Unreal Development Kit).

The interactive narrative is an extended version of our previous implementation based on a medical drama [9], featuring a junior female doctor who faces adversity as the narrative unfolds. Characters' expressions, combined with the use of filmic conventions in shot selection and camera placement, facilitate the induction of appropriate feelings towards the feature character.

Narrative generation is parameterised so that the narrative evolves spontaneously towards the character's demise unless she receives support from the user. Such support takes place through a short (30s) NF session, which is triggered dynamically when the character's situation deteriorates beyond a certain threshold. The NF signal is based on pre-frontal EEG alpha asymmetry, as a measure of approach/withdrawal towards the character. Since

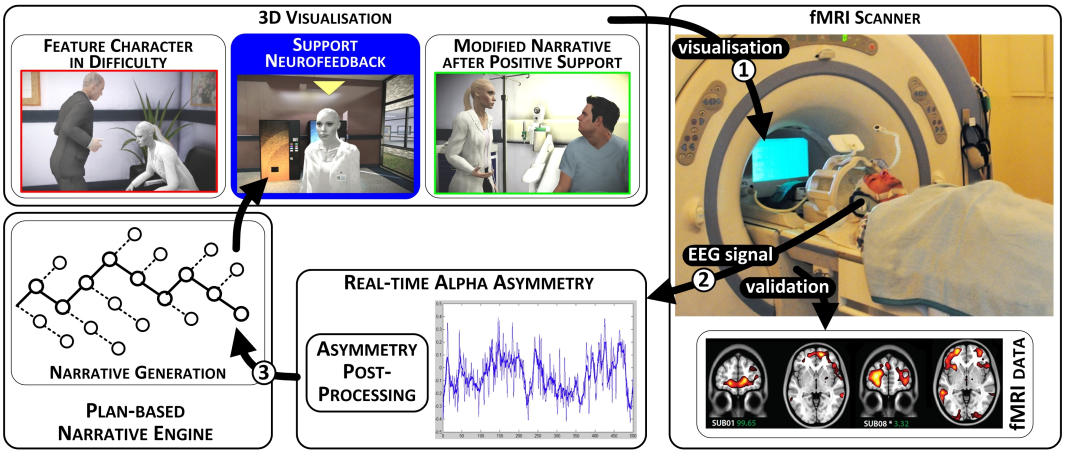

Figure 1 Integration of a BCI in an Interactive Narrative: (1) the user watches the narrative generated in real-time from inside an MRI scanner; (2) BCI input is mapped directly into the planning domain representation; (3) re-planning is triggered with successful levels of user support derived from neurofeedback; (4) visualisation continues with actions from the modified narrative.

NF implies volitional control rather than passive measurement, subjects require a cognitive strategy to control the NF signal. In order to develop such a strategy they receive minimal instructions which consist of "supporting the character by expressing positive thoughts".

From an implementation perspective, NF input is mapped to fluent values in the planning domain (see section 4), while on the graphics side, the NF backchannel is incorporated within the same visualisation mechanism as the narrative.

4 Narrative Generation

As the objective of the system is to test user support for a feature character, the system is required to generate narratives that contain negative situations for the feature character in the early stages of the narrative in order to show the character in challenging situations and hence provide opportunities for the user to support them. When users are able to successfully support the feature character, the narrative is required to be dynamically re-generated to reflect this success, with the narrative evolving towards positive outcomes for the feature character. However, if user support is unsuccessful then the original narrative continues to evolve with the overall trajectory skewed towards endings with negative outcomes. Thus narrative generation to test user support was implemented with a plan-based generator extended to use the following: *landmarks* to control early skewing of the trajectory towards negative situations and subsequent resolution towards negative or positive outcomes depending on NF success (section 4.1); representational mechanisms for the classification of actions depending on their valence (section 4.2); and triggering of user support opportunities (section 4.3).

4.1 Planning Trajectory Control

Landmarks, as introduced by Porteous et al. [22], are used in the system to provide a general mechanism to control the trajectory by ensuring the inclusion of actions with negative outcomes in the early phases of the narrative and actions with negative or positive outcomes

Figure 2 Examples of actions during which the feature character becomes *in-difficulty* are highlighted in grey.

towards the end of the narrative depending on user support success. Landmark facts represent narrative situations of interest that are used as intermediate goals around which the narrative is constructed. Examples in the medical drama genre could include such things as tense clinical situations, strained relationships, confrontations and deceptions. The landmarks and partial orders over them are specified as part of a PDDL3.0 planning domain model, as shown in Figure 3. The model is used in a decomposition based planning approach which starts by linearising the landmarks to form a total order. For Figure 3 this might be:

(i) *(harassed-by DrMacnair DrHathaway)*,
(ii) *(humiliated DrMacnair)* and
(iii) *(and (patient-outcome Jones) (doctor-outcome DrMacnair))*.

Then the narrative is generated as a sequence of sub-narratives with each of the ordered landmarks as the next sub-goal. The output narrative is produced by concatenation of the sub-narratives.

The use of landmarks in this way ensures the generation of narratives containing suitable dramatic content in the desired relative position in the narrative. To ensure that there is variation between generated (and re-generated) narratives, planning problem instances are automatically created at run-time using non-deterministic selection of initial state facts and landmarks from sets of candidates.

4.2 Valence of Actions and Landmark Selection

Narrative actions in the domain model and the facts they achieve are categorised on the basis of their valence, that is, whether they are positive or negative for the feature character: whether they create or alleviate difficult situations as characterised by the landmark facts the actions achieve. The system uses this valence information and the current level of user NF support to determine the choice of landmarks for narrative generation (or re-generation). Whether a particular landmark will lead to the generation of a narrative with appropriate dramatic content depends on its valence, for example, actions that achieve landmarks which

```
(:constraints (and
    (sometime-before
      (patient-outcome Jones)
      (humiliated DrMacnair))
    (sometime-before
      (doctor-outcome DrMacnair)
      (harassed-by DrMacnair DrHathaway))
    (at-end (and
      (doctor-outcome DrMacnair)
      (patient-outcome Jones))) ... )
```

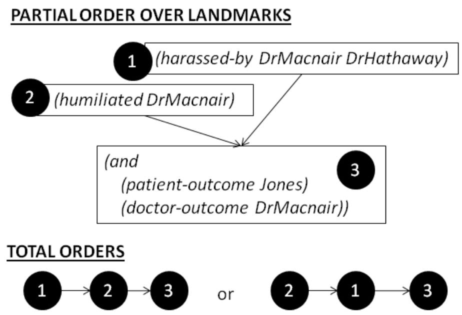

Figure 3 Example Landmarks: the left-hand side contains a selection of landmark facts represented using the PDDL3 modal operators *sometime-before* and *at-end*; on the right-hand side the order specified over the landmarks is represented graphically. The ordered landmarks are used in a decomposition-based planning approach to narrative generation: first, if the landmarks are partially ordered they are linearised to form a total order (the figure shows the consistent total orders, one of which is non-deterministically selected by the system); then each landmark in turn is used as a sub-goal and the narrative is built up incrementally from the sequence of sub-narratives (see text for more detail).

are adverse to the feature character are suitable for phases of the narrative showing their demise, whereas actions which are supportive towards them provide appropriate content for the evolution of the narrative towards a positive ending. As an illustration consider the actions shown in Figure 4 in which *receive-reprimand-from-boss* and *receive-professional-praise* have been categorised as adverse and supportive respectively: receiving a reprimand from the boss is clearly adverse for the feature character as it creates a difficult situation for them (as shown by the level of *in-difficulty*) and leaves them feeling humiliated, whereas an action such as receiving professional praise can be seen as supportive since it engenders positive feelings and alleviates the difficulty of their situation. The actions *patient-come-round* and *patient-die-despite-emergency-treatment* are illustrative of actions that acquire their significance in context. For our domain model, amongst a baseline set of 50 narrative actions, 5% can be categorised as adverse to the feature character, 20% as supportive and the remainder are neutral but acquire their significance in context. With this representational approach, the combinatoric nature of narrative generation is preserved, since the configuration of states considered at run-time comes from the entire set of actions, rather than just those specifically tagged as adverse or supportive.

4.3 Invoking User Intervention

Due to the demanding nature of NF, during which the user is required to concentrate in a manner that is difficult to successfully maintain for long periods of time, user interaction with the system can be limited to a single support opportunity[1]. The point in the narrative at which this occurs is dynamically determined based on the difficulty of the feature characters' situation, with user support opportunities being provided when this deteriorates beyond a threshold, and not on the basis of fixed story points. As the narrative unfolds and actions

[1] In our proof-of-concept experiments, unsuccessful users were offered a second support opportunity. In our more recent usability experiments, user support was limited to a single opportunity. Here, we restrict discussion to the dynamic triggering of this single request although the same principles apply in the case of an additional request.

```
(:init
    (= (in-difficulty) 0) (= (level-of-support) 0) (= (full-support) 2) (= (partial-support) 1)
    (= (no-support) 0)... )
```

ADVERSE

```
(:action receive-reprimand-from-boss
 :parameters (?d - doctor ?b - boss)
 :precondition (and
   (missed-work-deadline ?d) ... )
 :effect (and
   (increase (in-difficulty) 1)
   (humiliated ?d) ... ))
```

SUPPORTIVE

```
(:action receive-professional-praise
:parameters (?d1 ?d2 - doctor ?p - patient)
 :precondition (and
   (= (level-of-support) (full-support))
   (emergency-treatment ?d1 ?p)
   (patient-ok ?p) ... )
 :effect (and
   (when (>= (in-difficulty) 1)
      (decrease (in-difficulty) 1))
   (flattered ?d1) ...))
```

SIGNIFICANCE FROM CONTEXT

```
(:action patient-come-round
 :parameters (?d - doctor ?p - patient)
 :precondition (and
   (= (level-of-support) (full-support))...)
 :effect (and
   (patient-ok ?p) (patient-outcome ?p)
   (when (>= (in-difficulty) 1)
      (decrease (in-difficulty) 1)) ...))

(:action patient-die
 :parameters (?d - doctor ?p - patient)
 :precondition (and
   (= (level-of-support) (no-support))
   (not (patient-ok ?p)) ... )
 :effect (and
   (deceased ?p)
   (patient-outcome ?p)
   (increase (in-difficulty) 1) ... ))
```

Figure 4 Narrative Action Valence Examples. Action *receive-reprimand-from-boss* can be seen as adverse for the feature character since it engenders feelings of humiliation (represented using the fact *humiliated*) and results in difficult situations for the character (represented via the increase in the fluent *in-difficulty*). In contrast, the action *receive-professional-praise* is supportive: it results in positive feelings for the feature character (represented via the fact *flattered*), and improves the characters situation (represented via the decrease in *in-difficulty*). The actions *patient-come-round* and *patient-die*, which lead to states in which the patient treatment is resolved (via the fact *patient-outcome*), gain significance from the context of the actions.

are visualised to the user, the situation of the character is monitored by the system and when the difficulty of their situation has deteriorated beyond a threshold value (assessed via the fluent *in-difficulty*), a user support opportunity is triggered and signalled to the user (via de-saturation of the characters' appearance as discussed in section 5). This is immediately followed by the display of a custom scene featuring the character of interest which serves as a visual channel for NF whilst preserving visual consistency. Figure 2 illustrates the process of dynamic positioning of the user support opportunities for different narratives.

Following user interaction the level of user support detected through NF is communicated to the narrative generator, via the fluent *level-of-support*, whose value is directly updated with the NF results: 0 for no support; 1 for partial support; and 2 for fully successful user support. The response of the system depends on whether the user has been successful at supporting the character:

- If the user is successful, either fully or partially, then the remainder of the narrative is immediately regenerated by re-planning using a planning problem instance revised to include both supportive landmarks or those which depend on context, and the current state of the narrative world which now includes the updated *level-of-support*. This will redress the course of action to favour the feature character. For example, the action *patient-come-round* shown in Figure 4 includes a pre-condition which ensures that this action can only appear in narratives when user support has been fully successful (represented via the equality test between *level-of-support* and *full-support*).

- If the user support attempt is unsuccessful, the original narrative resumes its execution leading to a negative ending for the feature character.

5 Frontal Asymmetry Neurofeedback

As our BCI paradigm is based on pre-frontal alpha EEG asymmetry, we have adapted the asymmetry score A2, derived from work conducted by Henriques and Davidson [13] and further refined and implemented by Hammond and Baehre [11]. As α rhythm (8–12Hz) reflects cortical hypoactivity, an increase in left frontal activity corresponds to a positive A_2 score (which we measure as $(F_4 - F_3)/(F_4 + F_3)$ with $F_4(R)$ & $F_3(L)$ electrodes with a reference electrode at position FCz, using the 10–20 electrode placement standard). The NF mechanism involves the user modulating this activity using an appropriate cognitive strategy, attempting to achieve the highest ratio of *left vs. right* cortical activity they can (i.e., a positive A_2 score tending towards 1). Since A_2 is a measure of approach [29], an appropriate cognitive strategy would reach out to the character ("support"). Although A_2 is considered valence-independent [12], "positive thoughts" are often empirically successful, probably because they involve a dimension of approach as well. The backchannel for NF is purely visual and expressed as the colour saturation of the feature character, normalised from 0.0 (de-saturated) to 1.0 (rich saturation), as illustrated in Figure 2.

NF itself takes place over a 30s window, during which a static scene is displayed, with the main character in mid-shot (Figure 1). During NF, if the character's appearance remains de-saturated, this indicates the viewer has not successfully communicated their positive thoughts (i.e., has a minimum or below-threshold asymmetry score). Saturation is increased as the asymmetry score increases, mapped through a sigmoid function, to avoid over-saturation. When the character is fully saturated with colour and the viewer is able to maintain this (by successful modulation of a higher asymmetry score), this is recognised as successful support and generates the corresponding modification of the *level-of-support* fluent in the planning domain, thereby triggering re-planning to produce a happier narrative progression and ending.

6 Experimental Study

We designed this proof-of-concept study as a simultaneous fMRI/EEG experiment for which the information on activated loci gathered from fMRI scans serves to validate the areas (cortical and sub-cortical) involved during the support window. fMRI measures brain activity by detecting associated changes in blood flow, through a contrasting technique known as BOLD. This dual approach was necessary due to the low spatial resolution of the EEG signal. MRI has higher spatial resolution, but is integrated over longer time periods. We hypothesized that successful prefrontal neurofeedback would activate mainly frontal areas that were previously identified as related to emotion regulation. We also expected no significant extra activity in motor-related cortical areas, which could otherwise indicate non-specific affective function.

Fifteen healthy volunteers (3 female, 3 left-handed) with a mean age of 29.38 years (S.D. 7.6) and with either perfect or corrected eyesight took part in the experiment. Of these, two were discarded due to technical issues, and 1 was rejected subsequently because of severe EEG movement artifacts. EEG data was acquired using a 32-electrode MRI-compatible

BrainAmp MR system (from Brain Product Co.). Data was recorded at a sampling rate of 5000Hz and collected on a PC running RecView software for gradient and cardioballistic artifact removal. Alpha band (8–12Hz) power was extracted online from electrodes F_3 and F_4 as mentioned in Section 5, sampled in 500ms windows. The mean A_2 asymmetry score was calculated for each window, and this was used to drive NF visuals. Simultaneous to EEG recording, subjects underwent fMRI measurement with a 3T GE scanner. fMRI scanning was based on the echo-planar imaging (EPI) sequence of functional T_2^*-weighted images (TR/TE/flip angle: 3,000/35/90; FOV: $20 \times 20\text{cm}^2$; matrix size: 128×128) divided into 39 axial slices (thickness: 3mm; gap: 0mm) covering the whole cerebrum. A T1-weighted anatomical scan was used for alignment.

As narrative evolution for each subject is driven by neural activity during support opportunities, the length of experimental runs was somewhat variable. A typical run consisted of a NF training session (∼4 min.), a narrative training session (∼8 min., running through an example narrative outside of the MRI), an active session (∼8 min.), and a replay session (∼8 min.). Additional MRI scans of around 20min were needed to measure brain anatomy. To determine the controllable asymmetry range for each subject, we used the distribution of asymmetry scores from the training session, thus accounting for individual differences in baseline EEG trait asymmetry score. The active session began with 60s of blank screen followed by the Interactive Narrative that contained up to two opportunities of support through NF (30s each), dynamically generated by the system as a function of narrative evolution. The replay session consisted of the visualisation of the narrative generated by the same subject during an active session, with the interaction mechanism disabled, thus serving as a control baseline for fMRI. This could only be determined after the fact due to the variability in storyline.

6.1 Data Analysis

We operated under the assumption that the A_2 at baseline is a stable trait metric that can be shifted due to affective mental process during the active NF session. To characterise the relative change in the asymmetry during the active support window, we calculated for each subject the distance between baseline A_2 calculated from the rest period at the beginning of the active session, and both NF windows using a repeated measures ANOVA. When comparing this EEG measure against successful ability using the NF approach to alter the course of the narrative, five subjects had "successful" narrative outcomes combined with significant up-modulation in A_2 scores ($p < 0.1$, 4 with $p < 0.05$). This is shown in Table 1. With these subjects we can be confident that the successful use of the BCI was due to actual modulation of EEG. An additional subject had borderline significant up-modulation (subject 12). Three additional subjects had successful outcomes from the Interactive Narrative, but no significant up-modulation of A_2 scores, indicating some possible over-sensitivity in the calibration for those subjects (10,13,14). Three subjects showed significant negative relative A_2 scores, so were unsuccessful in the use of the BCI († in Table 1). What we aim to show is that, while BCI input is determined through the relative A_2 scores, brain imaging could not detect activity in areas associated with affective control, contradicting those EEG scores. While the BCI itself still appears to possibly benefit from further tuning with regard to sensitivity, it provided the correct outcomes for significant changes in EEG.

Analysis of fMRI data was performed with the SPM5 MATLAB tool. This includes preprocessing of fMRI data: (a) slice timing correction to the middle slice, (b) correction for head movement by realignment of all images to the mean image of the scan using rigid body transformation with six degrees of freedom, (c) normalisation of the images to Montreal

Table 1 *EEG NF relative change index.* **, * *- significant positive change* ($p < 0.1$, $p < 0.05$). $^{\diamond}$ *- borderline success.* † *- negative change, no effect on narrative.*

Sub	F	df	P	Sub	F	df	P
1^{**}	99.65	242	.00	13	1.56	242	.21
2^{**}	16.11	244	.00	14	0.6	244	.438
7^{**}	7.06	242	.00	10	0.02	240	.89
8^{**}	3.32	242	.04	$6^{\dagger}$	0.84	244	.36
9^{*}	3.00	244	.08	$5^{\dagger}$	5.57	242	.01
$12^{\diamond}$	1.94	244	.16	$4^{\dagger}$	15.48	244	.00

Neurological Institute (MNI) space by co-registration to the EPI MNI template via affine transformation, and (d) spatial smoothing of the data to 6mm full-width at half-maximum (FWHM). Finally, the first six images of each scan were discarded to allow for T_2^* equilibration effects. Statistical analysis was based on individual maps of activation obtained from a general linear model (GLM). The GLM included regressors that model epochs of active support during the live narrative session and epochs during replay of the support sessions within the replay of the previously generated movie. All regressors were convolved with a canonical hemodynamic response function (see model response in Figure 5 B). To reduce the effect of physiological artifacts and nuisance variables, six motion parameters were introduced as covariates in the model. T-statistical maps were obtained by contrasting hemodynamic responses during epochs of active support versus replay of these epochs.

6.2 Results

For further analysis we compared two groups: *successful* – those who significantly increased the A_2 score during the support period, and *unsuccessful* – those who did not modulate it significantly or in fact, reduced it. Since the BCI principle is a priori focused on changing the narrative positively, for validation of the method, we concentrated on the six individuals who were successful in up-modulating their A_2 score as well as having a positive narrative outcome.

6.2.1 Behavioural Analysis: User Debriefing

We inspected the reported subjective state of all subjects: the consensus emotion in the unsuccessful group was frustration (4 out of 6), while the successful group reported approach-type behaviour (i.e., empathy and positive emotions). Subjects quite clearly identified the protagonist of the story as “kind” and the antagonist as “vicious”, the only dissenting opinion being two subjects who characterised the feature character as “neutral” rather than “kind”. Personal perception of the extent to which the viewer was helpful or able to make a difference in the story was split, with successful subjects agreeing that they were helpful to the main character and had an impact on the story. These results, along with informal feedback, indicate that subjects did understand the dynamics of the narratives and that subjective perception of their effectiveness was aligned with successfulness of response as measured through NF input and corresponding fMRI data.

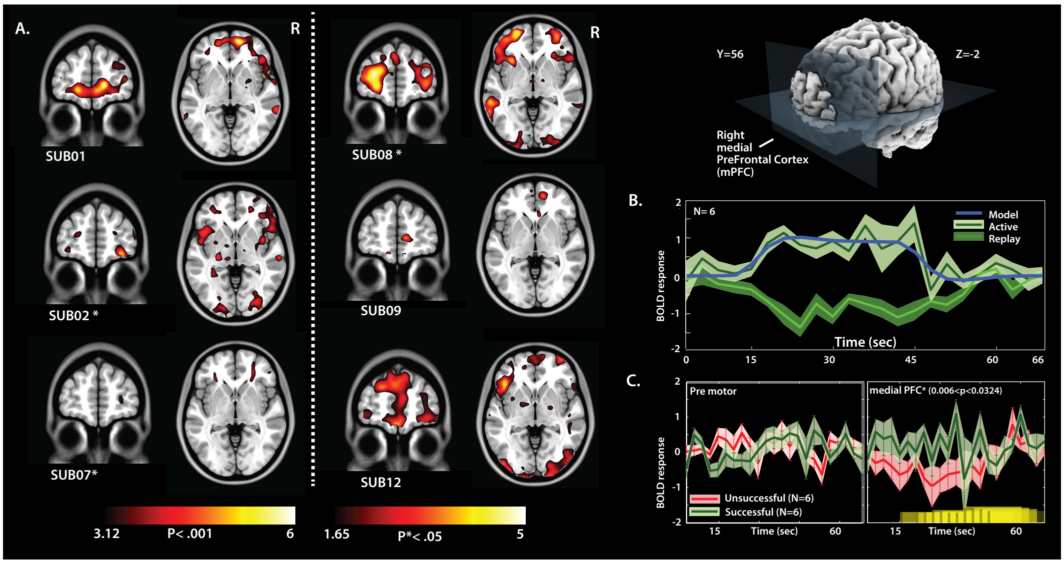

Figure 5 Brain validation of BCI for Interactive Narrative. **A.** Slice views (coronal and horizontal as indicated in top-right) of fMRI activation maps overlaid on a template anatomical scan (SPM5). Slices are shown for 6 out of 12 participants who were highly successful in modulating their EEG alpha asymmetry index during active support periods. The parametric activation maps were obtained by whole brain contrasts of active and replay sessions ($p < .001$, $p* < .05$). **B.** Time course of averaged estimated effect ($n = 6$) obtained from the contrast of active *vs.* replay from peak activation in a selected ROI in the right medial prefrontal cortex (see 3D location, top-right). **C.** Comparisons between successful and unsuccessful participants (green and red plots, respectively) in % signal change during the support period obtained from a relevant region of interest localized at the vmPFC, and from a non-relevant region in the premotor cortex. There is a significant difference in BOLD response between the groups for the vmPFC, with the successful group showing greater change (yellow squares indicate a sliding window of 24s in variable significance $0.006 < p < 0.0324$), while in the premotor, there is little difference.

6.2.2 fMRI Analysis of the Interactive Experience

Whole-brain General Linear Model (GLM) analysis of the fMRI data on the 6 individuals who were successful in A_2 up-modulation revealed enhanced activation during the periods of user support via NF, relative to the same periods during passive replay, in a cluster of regions in the pre-frontal cortex (PFC). These prefrontal loci include anterior and medial aspects of Brodman Areas 10 and 11 (BA10, BA11), known to be involved in cognitive and emotional control processes. Figure 5 shows the significant increased activation obtained in these PFC loci, confirming that successful up-modulation of EEG alpha asymmetry resulted in relevant regional recruitment. The whole-brain GLM analysis also provided additional indications of successful support-related regional activation in the middle temporal gyrus and the anterior insula. Only three of the successful supporters activated these regions at a threshold of $p < 0.001$ (uncorrected), but none of the unsuccessful supporters did so.

Intriguingly, signals obtained from the peak of activation within the PFC in each of the successful participants suggests that they not only increased their activity during the active user support, but also decreased it during the same period of the replay session (see Figure 5 B). To test the anatomical specificity of this regional effect we calculated time courses of activation during the active support window for each group in two distant loci: one in a task-relevant area in the anterior aspect of the PFC (BA10, MNI: 26, 58, 6, selected based on the overlap of successful activation maps at p < 0.05), the other in a non-task-relevant area in the right pre-motor cortex (BA 6, MNI: 56,6,48, selected based on the overlap of unsuccessful activation maps, at $p < 0.3$) (see Figure 5 C). A direct comparison between these traces showed that only activation changes in the PFC loci clearly distinguished between successful and unsuccessful individuals (sliding-window independent $t - test\, 0.008 < p < 0.0222$ FDR corrected).

6.2.3 Discussion

Considering the preliminary nature of the experiment and the limited size of our subjects' sample, we should naturally exercise caution in the interpretation of the above results.

In this experiment, we have endeavoured to provide generic instructions to our subjects, such as "mentally supporting" the main character, to avoid influencing their cognitive NF strategies. As a consequence, subjects did report variable strategies for producing such mental support, but the fMRI component of our experiments confirmed the selective activation of the BA10 area, known to be involved in mentalisation (i.e., reflection on one's own emotion and mental states, or those of other agents), a process also related to empathy [20]. Furthermore, our results suggest that the modulation of the A_2 EEG signal is not derived from premotor areas (Figure 5), a commonly used marker in BCI [10, 24] (notwithstanding potential limitations introduced by the left-handed fraction of our subjects' sample). Taking into account the complexity and variability of empathic processes and the multiple regions involved, it is difficult at this stage to draw further conclusions on the most relevant subregions of the PFC (e.g. dorso-lateral or ventro-medial, corresponding to different processes of cognitive and affective control) whose activation would constitute a further validation.

Another well-described difficulty of this type of simultaneous EEG/fMRI experiment derives from the difference in response times between EEG-based A_2 input and the BOLD signal. This is why we have presented results through a 60s window spanning 15s before and 15s after the NF window. The fact that activity in the mPFC would peak after 20s during fMRI recording (Figure 5 B) actually places it early in the NF phase and is consistent with many temporal patterns observed for A_2 variations during NF across our various experiments.

Overall, we can reasonably conclude that our fMRI findings are not incompatible, both from a spatial and temporal perspective, with the affective modulation mechanisms generally associated with A_2 asymmetry.

7 Usability Experiment

Following our proof-of-concept study, we staged a new experiment to assess the usability of the BCI for Interactive Storytelling, using a desktop implementation in a normal laboratory setting (outside of the MRI scanner). This experiment comprised a number of objectives: (1) to measure overall success scores and compare them to those of the proof-of-concept experiment; (2) to gain a better understanding of user cognitive strategies during NF; (3) to acquire data on the dynamics of NF; and (4) to explore the determinants of "BCI illiteracy" in this specific implementation of frontal alpha asymmetry NF [33].

We modified our previous prototype to improve the NF mechanisms, taking into account various observations of the baseline A_2 values, their variation across subjects and their typical variations during NF. Our first decision was to apply some form of filtering to the raw A_2 value to compensate for its variation: we opted for a 4-point moving average calculation

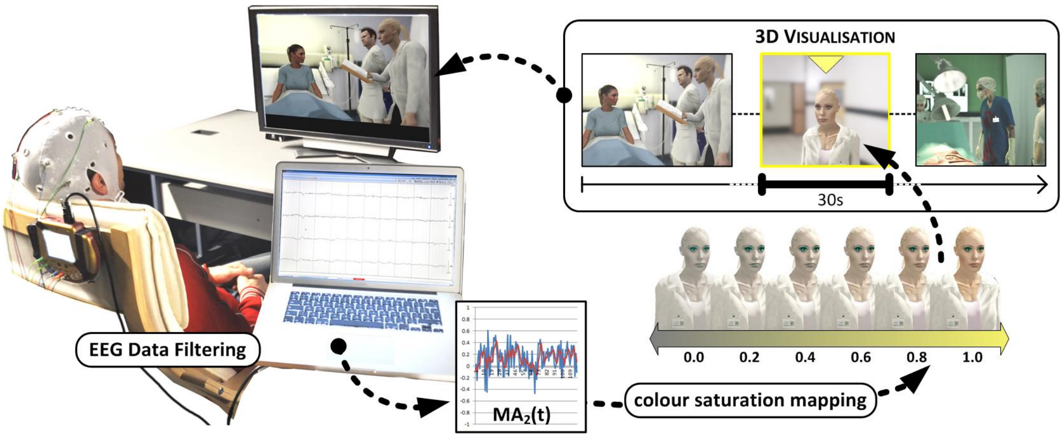

Figure 6 Usability experiment setup of our Interactive Narrative BCI prototype: (1) the user watches the narrative generated in real-time; (2) during NF, $MA_2(t)$ is mapped to the colour saturation of the character in need of support (see text).

(henceforth MA_2) as a simple form of low-pass filter and a compromise between filtering and delaying the averaged A_2 response. A second modification was to determine more accurately the variation range to improve NF mapping. We defined the threshold (NF feedback at 0% saturation) as the average A_2 value obtained for each subject during calibration at rest and, having observed empirically the maximum values reached for A_2 across multiple subjects, we defined a point corresponding to the maximum NF signal (100% colour saturation). This maximum was defined as: $min(max(MA_2), threshold + average\_variation)$[2]. To implement NF visual feedback we defined a linear mapping [0-100%] between the threshold and the above maximum. Finally, we revised the calculation of a success score for NF: it can be approximated by the integral of $MA_2(t)$ above threshold, over the 30s NF epoch. In order to normalise the score across subjects we used a block addition of the saturation value, resulting in a score between 0 and 100. We defined *success* (narrative support = 2) as a score > 20, which is equivalent to sustaining 100% saturation over 6s. *Moderate success* (narrative support = 1) corresponds to a value between 5 and 20.

In terms of data acquisition, EEG data was acquired using an 8-channel Brain Products V-Amp system. Data was recorded at a sampling rate of 250Hz and collected on a PC running Brain Vision RecView software. Alpha band (8–12Hz) power was extracted online from electrodes F_3 and F_4, sampled at (∼1 Hz) with a reference electrode at FC_z. The mean A_2 asymmetry score was calculated for each 1s window, and this was used to drive NF visuals. The pre-processing algorithm was compiled from Matlab R2013b to Microsoft .NET, so that it could be executed within the Brain Vision RecView EEG Recorder system. Raw EEG data was collected by Brain Vision RecView at a sampling rate of 250Hz. Data was then restructured to fit EEG offline data structure, packaged into MATLAB data types and marshaled to the MATLAB.NET compiled DLL. The MATLAB.NET compiled DLL calculated the A_2 momentary value once filtered through the calculation of a moving-average A_2 which was calculated over 4s, and passed this $MA_2(t)$ value back to the NF system, which in turn produced the appropriate feedback to the subject.

[2] Only "threshold" is related to the individual subject: other values have been obtained through a calibration study involving multiple subjects, different from the evaluation sample.

We recruited 36 subjects (17 male, 19 female); average age was 30.4 years (S.D. = 9.25; range: 20-52). Experiments were approved by our local ethics committee, and subjects were issued detailed consent forms. All data were anonymised, both questionnaire and EEG-related measures. For this experiment, subjects were located in a quiet room with dimmed lighting and sat in a comfortable armchair. They were given instructions on how to relax to minimise muscular artefacts as well as to avoid blinking as much as possible. Each subject went through a short calibration and training session prior to the Interactive Narrative experiment. This consisted of a 2min recording of A_2 scores to determine the individual subject baseline. This duration has been previously shown as the minimum duration that can provide reliable data [1]. During this baseline measurement, subjects alternated between eyes closed and open following a randomly selected COCO / OCOC pattern. Subjects subsequently went through a short training session, which gave them the opportunity to familiarise themselves with the NF system. The training system exactly reproduced the setting of the in-story input, except that it was not preceded by any narrative sequence (hence subjects can be considered to enter a training block in an affective neutral state, in particular since each training block was preceded by a short resting period). Each training block consisted of a 30s NF session, preceded by a 15s resting period during which subjects were instructed to relax and remain staring at a blue screen. Each subject went through 12 successive training blocks for a total duration of 10min: all subjects completed the training session.

The principle behind the BCI approach was explained to the subjects, as well as the use of NF as an interaction mechanism. They were told that they could support the story character by "expressing positive thoughts" that would be captured by the system. They were introduced to the concept of a NF loop in simple terms, with grey levels introduced as a visual indicator of the intensity/magnitude of mental support. Throughout training and evaluation, instructions were deliberately generic, in order to avoid influencing users' cognitive strategies towards any implicit or explicit one. In particular, we conspicuously avoided the use of terms such as empathy, sympathy, or other vocabulary likely to influence strategies (e.g. "talk to the character"). After the training session, each subject participated in one session of the BCI-enabled Interactive Narrative. Each subject saw a dynamically-generated variant of our medical drama, in which one NF session appeared as soon as the situation of the feature character deteriorated (although this is determined dynamically for each generated story variant, rather than pre-defined). Unlike with our proof-of-concept study, users only had a single opportunity to influence the course of action through a 30s NF session.

As described in section 4, we defined two levels of support: 1 for scores between 5 and 10, and 2 for scores above 10. Out of 36 subjects, 17 were unsuccessful, 7 were successful to a level of support of 1 and 12 were successful to a level of support of 2. The average score for successful subjects was 20 (S.D.: 25.98); this was essentially due to the contribution of two high-performing subjects: excluding them from this statistic, the average score is 12 (S.D.: 10.74). The overall success rate of 52.7% is modest for a usability experiment, but certainly above average when considering performance of previous frontal alpha asymmetry NF systems, in particular in clinical applications, and the very limited training undergone by subjects. It should also be noted that we have adopted a relatively demanding criterion for success, if compared to previous reports of frontal alpha asymmetry NF and even our proof-of-concept study. Previous (clinical) work reported hours of training over multiple sessions: here subjects had a single 10min training session[3]. We used limited training in this instance for practical as well as more fundamental reasons: frontal alpha asymmetry training is known to alter mood, and potential long-term effects were not covered by our ethical approval. This raises the possibility that if users had been subjected to the same type and level of training as in previous work, performance could have been much higher.

It is also worth investigating whether the concept of BCI illiteracy has any specific application to the case of frontal alpha asymmetry NF. BCI illiteracy was originally introduced to account for intrinsic non-performance of a stable fraction of the population, in the range of 15-30% [33] and is also recognised to be specific to the chosen BCI methodology [34].

Although BCI illiteracy is unlikely to constitute the sole explanation for the observed results, we have investigated, as a possibly specific determinant of illiteracy, the A_2 baseline of individual subjects, which we used in defining the NF threshold. The rationale is to estimate the maximum variation of A_2 during NF, in conjunction with the maximum values that can be empirically reached by A_2. This would suggest that individuals with a high A_2 baseline would be at a disadvantage to further increase their A_2 score as part of the NF process, making them less successful at using the BCI. This could also be related to the limited contribution of state variations to the total A_2 variation, estimated to be 10-20% [5]. To explore this phenomenon, we measured the correlation between in-story success and the A_2 baseline/NF threshold and observed a significant negative correlation (the point-biserial correlation between narrative support (collapsed) and threshold was $rpb = -.371, p = .026; Biserial : rb = .47, p = .026$), compatible with our initial hypothesis. We also investigated the cognitive strategies adopted by users for NF, in particular considering the non-prescriptive nature of instructions. We recorded free debriefing sections following each experiment and using their transcripts we categorised the users' declared cognitive strategies. We observed that no subject used implicit strategies, possibly as a consequence of our instructions mentioning "positive thought" (rather than letting thoughts wander whilst monitoring feedback). Explicit strategies were subsequently categorised as empathic *vs.* generic. The former directly target the virtual character such as inner speech or mental imagery (such as hugging or patting on the back). The latter express positive thoughts of a generic nature, such as recollections of pleasant moments in the subject's personal life, a strategy already reported in [15]. We found that support strategy during narrative and narrative success (merging levels of support 1 and 2) were not significantly related, $\chi^2(1) = 1.00, p = .51, V = .17$ (results were not altered when considering levels of support as separate categories).

However, when revisiting the above correlation between A_2 baseline/NF threshold and NF success for each group, we found that narrative success was negatively correlated with threshold in the generic strategy group ($r = -.56, p = .016$), but not in the empathic strategy group ($r = -.08, p = .767$). At the same time, threshold was not significantly different between the empathic and generic conditions ($t(34) = 1.21, p = .233$). These findings have to be interpreted in light of the variability of empathic responses, with only empathic cheerfulness strongly related to an increase in frontal alpha asymmetry [16]. This may actually limit the success of empathic strategies based on empathic concern [32]. Indeed, we found no correlation between empathic concern (part of the Interpersonal Reactivity Index (IRI) questionnaire[7]) and in-story success. On the other hand, positive personal experiences have proven efficient in previous NF studies [14] and were even reported as part of our proof-of-concept study.

[3]Rosenfeld [3] reports that some frontal alpha asymmetry EEG NF protocols require 40 days.

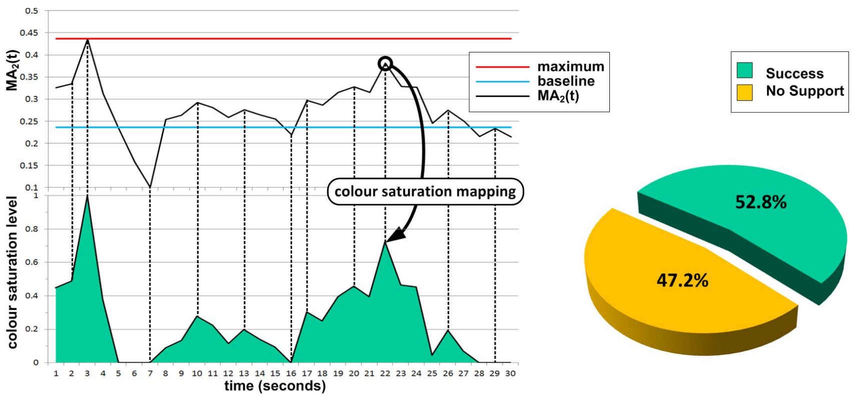

Figure 7 (left) Mapping of $MA_2(t)$ to the value of the virtual character's skin colour saturation in real-time and (right) overall success score in our sample (with limited NF training).

8 Conclusions

Affective BCI is a promising technique for Interactive Narrative, but its usability may be limited by the difficulty of all forms of emotional regulation. Our neuroimaging study has provided preliminary evidence for the importance of recruiting medial prefrontal regions that have been implicated in affective control as well as empathy-related processes for successful modulation of frontal alpha asymmetry. Although overall in-story success scores appear similar for both our proof-of-concept experiment and our usability study, the latter used slightly more stringent success criteria. Our overall score of 52.7% is certainly encouraging, even if not sufficient to guarantee usability: it is however important to analyse its significance, as well as any potential for improvement. Subjects tend to be distributed in two groups, successful and not, with very few intermediate values: this pattern could be construed as one of high-efficacy combined with high-illiteracy. The average score of successful subjects is 20, which corresponds to 100% saturation over 6s, equivalent to an increase in A_2 of over 0.2. This compares favourably with success criteria reported by Rosenfeld et al. [28] (number of "hits" per trial) or more recently Zotev et al. [37] (increases in A_2 up to 0.2, although in the high beta band).

In addition, there exists a real possibility that A_2 baselines have been overestimated due to the closed eyes recording epochs. Offline analysis of A_2 baselines values only considering open eyes epochs revealed an average difference of 0.10 ($t(35) = 6.61, p < .001$), which could have significant impact on performance, although this can only be validated through additional NF experiments. It should also be noted that although left-handed subjects are often excluded from alpha-asymmetry this was not the case in the present study. As left-handedness might bias frontal asymmetry measures by lowering the baseline level [23], possibly partially due to motor activity, left-handed subjects may perform the task of increasing the asymmetry more easily. Handedness-related difference could be statistically examined in the future, subject to the sample size being increased. Users have reported a mix of empathic and generic NF cognitive strategies. This source of variance – the type of empathic engagement entertained by the user during the feedback – should be better controlled for in future studies, as it is likely that users have adopted a mix of empathic strategies not all based on empathic cheerfulness. In this context, it is worth noting that Light and colleagues [16] reported that the direction of frontal EEG laterality may vary with the empathic strategy adopted by the person who feels empathy. They found that children who express cheerful empathy, when trying to encourage a suffering person, increased their right dorsolateral asymmetry, while the empathic happiness they shared with the individual once their suffering was relieved, was associated with left dorsolateral asymmetry. A focused debriefing on these aspects of empathy (possibly correlated to questionnaires such as IRI) will allow for a higher-resolution account for EEG and fMRI effects during the neurofeedback. However, some debriefing comments cast doubts on the extent to which some subjects actually engaged in NF, i.e. took full advantage of the visual feedback channel, as opposed to concentrating on providing an input signal. This can only be clarified through a detailed examination of temporal patterns, but the intrinsically noisy nature of EEG input may render this analysis challenging.

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The Need for Multi-Aspectual Representation of Narratives in Modelling their Creative Process*

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Abstract

Existing approaches to narrative construction tend to apply basic engineering principles of system design which rely on identifying the most relevant feature of the domain for the problem at hand, and postulating an initial representation of the problem space organised around such a principal feature. Some features that have been favoured in the past include: causality, linear discourse, underlying structure, and character behavior. The present paper defends the need for simultaneous consideration of as many as possible of these aspects when attempting to model the process of creating narratives, together with some mechanism for distributing the weight of the decision processes across them. Humans faced with narrative construction may shift from views based on characters to views based on structure, then consider causality, and later also take into account the shape of discourse. This behavior can be related to the process of representational re-description of constraints as described in existing literature on cognitive models of the writing task. The paper discusses how existing computational models of narrative construction address this phenomenon, and argues for a computational model of narrative explicitly based on multiple aspects.

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1 Introduction

Existing approaches to narrative generation tend to apply basic engineering principles of system design which rely on identifying the most relevant feature of the domain for the problem at hand, and postulating an initial representation of the problem space organised around such a principal feature. Additional features of the problem can then be considered as further constraints on the problem. Or, in cases where the simple formulation of the problem is complex enough, they may be postponed for later consideration. The idea being that a first approximation to the problem based on a single feature is a valuable contribution in itself. This is acceptable indeed as a first approximation, but the argument presented in this paper is that for progress to be made towards better modelling of the human narrative

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capacity, the integration of models of the different features or aspects observed in narrative must be attempted.

Engineering approaches of this type have been applied to the problem of narrative generation, and a number of particular aspects of narrative have been favoured as focal points of these research efforts. These aspects include the linear sequence of discourse, causality links between elements in the story, the underlying structure of the narrative in narratological terms, or the behaviour of characters and their interaction with one another.

It is easy to understand why the task of generating narrative has been addressed in such a fragmented way. Each particular approach leads to a representation of narrative that is conceptually different from the others. Each of the selected AI techniques relies on the specific representation over which it can operate easily. Success in terms of results on particular features of narrative needs to be measured over the corresponding representation. Current expectations on quick turn-around for scientific publications, or pressure for PhD theses to be finished in short periods of time, work against the decision to consider more than one such representation in a single approach.

The present paper addresses the problem of postulating a representation of narrative that combines several of the possible views on narrative into a representation capable of explicit reformulation. This representation should be capable of: representing explicitly all the features considered relevant for the automated treatment of narrative, shifting from one view to another, providing input data in formats valid for the application of those AI technologies that have been deemed good models of some aspect of narrative processing, allowing the application of metrics that measure the various relevant aspects of narrative, and generating specialized views of the narrative according to the set of features under consideration.

2 Related Work

Existing work on conceptual representation of narrative in terms amenable to computation can be found in two separate fields: in efforts to establish models of cognitive process related to narrative, and in efforts to review and classify existing systems for the generation of narrative.

2.1 Related Work on Theoretical Models of Cognition

Although a full review of the literature on cognitive and psychological models of the creative writing process is beyond the scope of this paper, three ideas from the field are reviewed to provide the basis for the arguments presented later in the paper. They are: Sharples' model of writing as a creative design process [40], Karmiloff-Smith's concept of Representation Redescription as a model of the role of representation in progressive acquisition of expertise [20], and the work by Trabasso et al in modelling the inferences made by readers in understanding stories [44].

2.1.1 Cognitive Models of the Creative Writing Process

Margaret Boden [6] formulated the creative process in terms of search in a universe of concepts. However, she specifies that the creative process of a particular creator does not traverse the complete universe, but only a conceptual space, a subset of the universe particular to that creator and the procedures he is employing. Such a conceptual space would be defined by a set of constructive rules. The strategies for traversing this conceptual space in search of ideas would also be encoded as a set of rules.

Sharples [40] presents a description of writing understood as a problem-solving process where the writer is both a creative thinker and a designer of text. For Sharples, the universe of concepts to be explored in the domain of writing could be established in a generative way by exhaustively applying the rules of grammar that define the set of well-formed sentences. The conceptual space on which a writer operates is a subset of this universe identified by a set of constraints which define what is appropriate to the task at hand. Sharples explains that the use of a conceptual space "eases the burden of writing by limiting the scope of search through long term memory to those concepts and schemas that are appropriate to the task" [40, p. 3]. To Sharples, the imposition of these constraints enables creativity in the sense that he identifies creativity in writing (in contrast with simple novelty) with the application of processes that manipulate these constraints, thereby exploring and transforming the conceptual space that they define. Sharples provides a specification of what he envisages these constraints to be. Constraints on the writing task are described as "a combination of the given task, external resources, and the writer's knowledge and experience" [40, p. 1]. He also mentions they can be external (essay topic, previously written material, a set of publishers guidelines. . .) or internal (schemas, inter-related concepts, genres, and knowledge of language that form the writer's conceptual spaces).

A special example of this kind of constraint on the writing task is the use of *primary generators*. Sharples observes that expert novelists, when describing what initiated their writing, often mention ideas that can be interpreted as primary generators. It is a fundamental starting point, providing a mental construct around which to form the text. He goes even further to affirm that "The skill of a great writer is to create a generator that is manageable enough to be realised in the mind, yet sufficiently powerful to spawn the entire text" [40, p. 15]. With respect to the way such constraints may be iteratively modified during the writing process, Sharples explains, that primary generators may be rejected or modified during the process, as the writer gains more insight into the problem.

Sharples also provides a description of how the typical writer alternates between the simple task of exploring the conceptual space defined by a given set of constraints and the more complex task of modifying such constraints to transform the conceptual space. Sharples proposes a cyclic process moving through two different phases: engagement and reflection. During the engagement phase the constraints are taken as given and the conceptual space defined by them is simply explored, progressively generating new material. During the reflection phase, the generated material is revised and constraints may be transformed as a result of this revision. Sharples also provides a model of how the reflection phase may be analysed in terms of specific operations on the various elements. People produce grammatically correct linguistic utterances without being aware of the rules of grammar, but to explore and transform conceptual spaces one needs to call up constraints and schemas as explicit entities, and work on them in a deliberate fashion. For the mind to be able to manipulate the constraints, they have to be subjected to a process of "representational redescription" [20], re-representing knowledge that was previously embedded in effective procedures as elements susceptible of manipulation.

The problem is that beginners addressing such a cognitive task do not have a vocabulary to describe mental processes to themselves. To learn, they must develop "a coherent mental framework of plans, operators, genres and text types that can guide the process of knowledge integration and transformation" [40, p. 5]. Experts tend to have such a mental framework that underlies and supports their writing efforts. For beginners, the problem must be addressed with the aid of general knowledge about how to design artefacts, how to transform mental structures and how to solve problems. Because this is difficult to do in the head, some writers resort to capturing the ideas involved in paper, as sketches, lists, plans, notes etc. These external representations stand for mental structures, and they are easier to manipulate. The writer can then explore different ways of structuring the content, apply systematic transformations, establish priorities, and reorder or cluster items. The task of writing addressed in these terms is much closer to recognised design tasks.

2.1.2 Representational Re-description in Progressive Acquisition of Expertise

The arguments outlined above with respect to how Sharples models the differences between beginners and experts suggests further consideration of the role of the evolution of representation in the progressive acquisition of expertise. In this respect, Karmiloff-Smith [20] proposes a model of evolving representation called Representational Redescription model.

This model analyses the development of behavioural mastery in a given domain – meaning consistenly succesful performance in the domain – in terms of how knowledge about the domain is represented internally by the individual. The model considers three phases of learning. During the first phase the individual focuses on his interaction with the environment, and represents these in the form of raw data received from outside. This may lead to an initial achievement of behavioural mastery. Over the second phase, internal representations are abstracted from the raw data, and processing may start to focus on them. As a result of this introspection, features of the environment may temporarily be disregarded and, as a result, observed behaviour may deteriorate. However, this leads to a recuperation of a more flexible achievement of behavioural mastery, by then based on having achieved reconciliation between internal representation and external data.

This model describes four different levels of cognitive representation: *implicit*, focused on the process itself; *explicit level one* in which basic aggregation of raw data present in the implicit level is performed in terms of data storage but may not yet be accessible to the cognitive system for manipulation operations; *explicit level two*, in which structures from the first explicit level are converted into schemas and thereby become available; and *explicit level three*, a final and "cross-system" representation of concepts that can be verbalized and are fully integrated in a more general cognitive system.

2.1.3 Models of Narrative Understanding

According to Trabasso et al. [44], comprehension of a story is seen as the construction of a causal network by the provision by the user of causal relations between the different events of a story. This network representation determines the overall unity and coherence of the story.

Graesser et al. [18] describe a constructionist theory that accounts for the knowledge-based inferences that are constructed when readers comprehend narrative text. In doing so, readers build a referential situation model (a mental representation of the people, setting, actions, and events that are mentioned in explicit clauses or that are filled in inferentially by world knowledge) of what the text is about [7]. The meaning representation so built must: address the reader's goals, be coherent at both local and global levels, and explain why actions, events and states are mentioned in the text.

Graesser et al. list 13 types of inference that a reader is likely to make on trying to understand a text. The full set of inference types and their description is given in Table 1.

Table 1 Types of inference made during narrative understanding, after [18].

Type of inference	Brief description
Class 1: Referential	Word or phrase referentially tied to previous element or constituent in text
Class 2: Case structure role assignment	Noun phrase assigned to particular case structure role, e.g. agent, object...
Class 3: Causal antecedent	Inference is on a causal bridge between current action (or event or state) and previous context
Class 4: Superordinate goal	Inference is a goal motivating an agent's intentional action
Class 5: Thematic	Main point or moral of the text
Class 6: Character emotional reaction	Emotion experienced by a character caused by or in response to an action or event
Class 7: Causal consequence	Forecasted causal chain, including physical events and new plans by the agents
Class 8: Instantiation of noun category	Exemplar that instantiates an explicit noun or case role required by a verb
Class 9: Instrument	Object, part of body or resources used when an agent executes an intentional action
Class 10: Subordinate goal action	Goal, plan or action that specifies how an agent's action is achieved
Class 11: State	A state not causally related to plot (agent's knowledge or beliefs, object properties, spatial location of entities)
Class 12: Emotion of reader	Emotion that the reader experiences when reading the text
Class 13: Author's intent	Author's attitude or motive in writing

2.2 Existing Taxonomies of Dynamic Computational Models of Narrative

There are a number of computational models of narrative that address the dynamic nature of the processes involved in the construction of narratives.

Such models have been reviewed in the past by many authors into taxonomies based on different aspects. Although these classification efforts do not necessarily consider the issue of what features of narrative are represented explicitly in each case, these taxonomies highlight some of the differences in focus between the various systems, and may provide a starting point for our discussion.

Bailey [4] distinguishes between the following models of story construction (in his case particularly applied to story generation):

author models in which the task of generation is approached from the perspective of a (human) author, and an attempt is made to model actual processes undergone by human authors during the creation of a story (cites as examples [24, 13, 45] and an early paper by [34]),

story models in which story generation proceeds from an abstract representation of the story as a structural (or linguistic) artefact (cites as examples [12, 39, 33, 26]),

world models in which the task of constructing a story is addressed obliquely, by constructing a "world" and the characters within it and imbuing them with sufficient agency and complexity that their action become representable as a story (cites as examples [28, 31]),

reader models in which the story generation process is guided by a model of the story in terms of its effects on the cognitive processing of the story by an imagined reader.

Gervás et al. [17] group story generation approaches within Artificial Intelligence into two groups, based on the techniques they employ:

planning/problem solving in which narratives are modelled as either a goal state to reach by applying story-construction operators or the result of story actions that the characters perform (cites as examples [45, 34]),

production grammars that model a narrative by defining the structural constituents of a story (cites as examples [39, 8, 43].

O'Neil [32] breaks down computational models of story generation into:

search based approaches which create stories by exploring the set of possible sequences of actions, typically comparing the generated story against some heuristic of quality [28, 24, 38, 36],

adaptation based approaches which use their knowledge of other stories to modify these stories into new ones [45, 34, 16].

Niehaus [30] distinguishes between:

simulations or emergent systems that primarily simulate the narrative world (cites as examples [2, 10, 19, 28, 35]),

deliberative systems those that primarily deliberate over the choice of narrative elements and events (cites as examples [3, 11, 25, 45, 27, 38]).

Niehaus explains that some recent simulation systems attempt to employ complex models of characters, and that deliberative systems tend to be guided by a set of narrative rules which define desirable stories [30]. Such narrative rules can be made to capture different features of narrative: classical plot structure, character dynamics, or even the experience of the reader.

This proliferation of different taxonomies all aimed at categorizing the field of narrative generation systems can be taken as an indication that the nature of the domain involves more aspects than can be accounted for in a single simple taxonomy. Whereas efforts of synthesis may be appropriate to summarise the field for purposes of communication, the present paper applies an effort of analysis in an attempt to understand this underlying complexity.

3 Aspects of Narrative in Terms of their Representation

This section establishes a number of significant aspects of narrative that can be drawn from the existing theoretical model of cognition related to narrative described in Section 2.1, and for each one of those it explores how they have been chosen as explicit focus of representation efforts in the past.

To clarify what is meant by an aspect in this context, each of the main aspects of narrative that have been chosen as explicit focus of representation efforts in the past are described briefly. In each case, some relevant examples are cited, though many more exist.

3.1 Selecting Relevant Aspects of Narrative

The set of inferences described by Graesser et al. [18] constitute a good reference for the basic elements that need to be considered during the process of constructing a narrative.

The 13 types of inference may be roughly grouped into the following categories: inferences needed to make basic sense of the language in which the text is written (referential, case structure role assignment, instantiation of noun category, instrument, state), inferences need to work out the causal relations between events in the text (causal antecedent, causal consequence, subordinate goal action), inferences need to work out the motivations of agents in the text (superordinate goal), inferences concerning the overall point or moral of the text (thematic), inferences concerning emotions (character emotional reaction, emotion of reader), and inferences concerning the goals pursued by the author in writing the text (author's intent).

It seems plausible to consider that these different types of inference might be a starting point for representing the constraints on the writing task that Sharples describes. The vocabulary that an expert writer develops over time would allow explicit representation of an ongoing draft along all these different dimensions. In contrast, a novice might have his vocabulary restricted to a subset of these.

Additional axes of representation of an ongoing draft might come about if the author is familiar with concepts of narratology. As this type of work may be extremely diverse in nature, and every author is free to pick out a particular model or theory as additional tool to help him in his task, no attempt has been made to review these extensively in the paper. Nevertheless, it is important to consider that such models of the structure of narrative may play a significant role in providing additional dimensions of representation of a draft during the process of constructing a narrative. Issues like narrative arc [1, 15], the hero's journey [9], or the morphology of the folk tale [37] may be used to analyse an ongoing draft and as additional vocabulary in which to phrase constraints on the process of construction.

The representation and processing of texts at the elementary linguistic level has been the subject of many years of research within the field of natural language processing. The basic mechanisms by which language conveys meaning are considered beyond the scope of this paper. However, for the purposes of story construction two specific aspects are considered relevant: the sequence of presentation imposed by a linguistic rendering, and the elementary representation of the activity of agents in terms of actions, interactions, movement between locations. We will refer to the first aspect as *discourse sequence*. Within this aspect we will consider the representation of a story simply a sequence of discourse elements, each of one representing a unit of meaning captured within the system in some conceptual representation. The second aspect we will refer to as *simulation*.

As a result of these considerations, the following list arises of possible dimensions along which to represent aspects of a narrative: the *discourse sequence aspect* (a sequential discourse of conceptually conveyed items), the *simulation aspect* (a representation of the activity of agents in terms of actions, interactions, mental states, and movement between locations), the *causal aspect* (a structured representation of causal relations between elements in the story), the *intentional aspect* (a representation of the motivations of agents), the *thematic aspect* (a representation of the theme of parts of the story), the *emotional aspect* (a representation of the emotions involved in or produced by the story), the *authorial aspect* (a representation of the intentions of the author), and the *narrative structure aspect* (representations of the story in terms of narratological concepts of story structure).

The remainder of this section will consider these resulting 8 aspects in terms of how (whether) they have been represented computationally in existing systems. The set of aspects considered here is not meant to be exhaustive. Those aspects that have been reviewed correspond to the ones that have been more frequently chosen explicitly as focal point for computational representations of narrative, but there are others.

3.2 The Discourse Sequence Aspect

A fundamental aspect of narratives is the fact that, whatever the internal complexity of the set of events they refer to, they are usually presented to the reader as a linear sequence of discourse units. Many of the computational approaches to narrative focus on this view as a linear sequence of discourse elements as the main representation of a narrative. These approaches represent stories as a sequence of statements or facts that is incrementally constructed. Over a representation in these terms, procedures are provided for progressively selecting which statement can be added to the draft at each point, to construct a complete story.

These approaches tend to focus on stories focalized on a single character, where a single narrative thread following that character is enough to cover the complete story. In cases where several characters are active at the same time in different locations this type of model may have difficulty in representing story events as they occur.

Mexica [34] generates linear sequences of actions by explicitly adding content to partial discourses in a computational implementation of the engagement and reflection model [41]. The discourse is constructed by an elaborate selection among actions that can possibly follow according to the current state. This generation is driven not only by knowledge structures defining the domain, but also by explicit curves that model the evolution of narrative tension in a linear discourse in such a way that the produced story lineally matches the objective curve. Many of the systems employing more complex underlying representations include an additional stage for the representation of discourse, with procedures for distilling it from their internal representation.

3.3 The Simulation Aspect

Another important aspect of narrative is the representation of characters, their behaviour, and the internal representation of their mental state, their relations with one another, their motivations, and their beliefs. This aspect has been chosen as focal point for the representation of narratives in some approaches to story generation. Such approaches concentrate on representing characters and rules that may govern their behaviour and interaction in such a way that they can be set in motion as an autonomous (usually agent-based) system.

The Novel Writer system developed by Sheldon [21] relied on a micro-simulation model where the behaviour of individual characters and events were governed by probabilistic rules that progressively changed the state of the simulated world with the flow of the narrative arises from reports on the changing state of the world model. Meehan's TaleSpin [28] models a story as the sequence of actions that characters perform to reach their objectives. The Virtual Storyteller [42] generates stories as the output of a agent-based interaction in which goals, perceptions and relations guide character behavior. The system includes a Director agent that, while not appearing in the story, communicates with the other agents and drives the interaction to look after its narrative features. Façade [27] is a one-act interactive fiction system in which agents interact with the user in natural language. Façade has a strong focus on character behavior definition. Lebowitz's UNIVERSE [23] was the first storytelling system to devote special attention to the creation of characters. The BRUTUS system [8] is described as having included a simulation-process is set in motion, where characters attempt to achieve a set of pre-defined goals and this results in a plot.

Beyond actual generation, the explicit representation of character beliefs, motivations, values, and moral dilemmas has been proposed as a crucial ingredient for the adequate treatment of narrative in legal contexts [5].

Narratives produced in terms of the simulation aspect then need to be collected or abstracted from the log of the collective behaviour of such a system into a narrative discourse.

3.4 The Causal Aspect

Efforts focusing on *causality* as main feature of narratives have lead to the application of planning approaches to narrative generation. In these, a story is represented as a graph or network of causal links that connect the description of its initial state to the description of its final state, and the representation of the story is built by the application of planning algorithms.

Reliance on some kind of planning algorithm is a feature of many existing story generation algorithms. TALESPIN [29], a system which told stories about the lives of simple woodland creatures, was based on planning: to create a story, a character is given a goal, and then the plan is developed to solve the goal. The operation of the UNIVERSE system [24] was similar to decompositional planning. MINSTREL [45] used building units consisting of goals and plans to satisfy them. Fabulist [38] used a planning approach to narrative generation. Since then, many more systems have used planning approaches as underlying technologies [3, 11, 36, 10, 35, 30, 32].

3.5 The Intentional Aspect

The planning approach focuses basically on the causal set of inferences. Inferences about motivation and the intention's of characters are not contemplated in a traditional plan, which focuses on actions, their preconditions and effects. As a refinement on the planning approach, the work of Riedl [38] extends this representation with additional information concerning intentionality, which is assumed to take a main role in character believability. Following this, Riedl's FABULIST performs story generation by applying a planning algorithm on partial stories in which characters' objectives and the plausibility of their intentions, along with author goals, drive the creation. The Intent-Driven Partial Order Causal Link (IPOCL) planning algorithm simultaneously reasoned about causality and character intentionality and motivation in order to produce narrative sequences that are causally coherent (in the sense that they drive towards a conclusion) and have elements of character believability.

3.6 The Theme Aspect

Theme is the central topic a text treats, the central meaning of a narrative. Theme has been identified as an important inference carried out by readers in understanding a story. Cognitive theories of narrative consider it very relevant. Graesser et al [18] consider theme among their set of inferences relevant to the understanding of narrative. The concept of theme also seems very close to what Sharples defines as primary generators, which he reckons have a fundamental role in the process of writing.

In spite of this, very few story generation systems have considered it. The MINSTREL [45] system was started on a moral that was used as seed to build the story. This moral was explicitly added at the end of the story. The BRUTUS [8] system included a specific process of instantiation of a thematic frame.

3.7 The Emotional Aspect

One particular aspect that deserves special attention is emotion. Emotion is a fundamental aspect of narrative that has surprisingly received little attention in terms of computational representation, possibly due to the difficulties inherent in representing such elusive concepts. A pioneer in this sense is the Mexica system [34] which includes explicit representation of emotional links between characters and drives the story generation process based on how these emotional links and the resulting emotional tensions rise and fall throughout the story.

3.8 The Authorial Aspect

The intentions of authors are fundamental in the construction of narrative. Many story generation systems have recognised this truth and built in representations of these intentions into their operation.

Dehn's AUTHOR [14] was a program intended to simulate the author's mind as she makes up a story. According to Dehn, an author may have particular goals in mind when he sets out to write a story. But even if she does not, it is accepted that a number of metalevel goals drive or constrain the storytelling process. These concern issues such as ensuring the story is consistent, that it is plausible, that characters be believable, that the attention of the reader is retained throughout the story etc. These may translate at a lower level into subgoals concerning situations into which the author wants to lead particular characters, or the role that particular characters should play in the story. A story is understood as "the achievement of a complex web of author goals". These goals contribute to give the story its structure, guiding the construction process, but they are not visible in the final story. Some example high level author goals are given: make the story plausible, make the story dramatic, and illustrate key facts. UNIVERSE [24] relied on a procedure similar to decompositional planning, but considered a set of goals that were not character goals, but author goals. This was intended to allow the system to lead characters into undertaking actions that they would not have chosen to do as independent agents (to make the story interesting, usually by giving rise to melodramatic conflicts). The MINSTREL [45] system relied on a planning system that operated at two different levels: in terms of author goals and in terms of character goals. Mexica [34] was a computer model designed to study the creative process in writing in terms of the cycle of engagement and reflection as capture in the cognitive model built by Sharples [41]. During the reflection phase, the system checks whether the story so far satisfies criteria of coherence and novelty. These may be considered author goals.

The intentions of the author are a fundamental aspect of narrative in as much as they provide the background against which all the other aspects need to be considered. Depending on the purpose that the author has in mind, some aspects will be more relevant than others for the final narrative. Different authors may decide to focus more on emotions, or the style of the discourse, or the narrative structure.

3.9 The Narrative Structure Aspect

Efforts focusing on the *underlying structure* of a narrative as the main feature of narratives envisage the representation of a narrative in terms of a skeleton that gives shape to it, and consider procedures for selecting or constructing such a skeleton and then progressively enriching it to a full narrative. Existing efforts rely either on Case-Based Reasoning (CBR) technologies [45, 16] or on grammars [12, 39, 43, 33, 26, 8] to achieve this. In some cases, this is achieved by reusing the structure of previously existing narratives, either by adopting a particular one wholesale, gutting it and then refilling it with new material, or by first combining the structure of several narratives to build a new skeleton, and then populating that with new material. In the spirit of making the most of available materials, these approaches tend to consider the task of refilling narrative skeletons in terms of reusing constituent elements from the set of prior narratives gathered as reference for narrative structures.

The MINSTREL [45] system applied a CBR procedure based on the application of Transform Recall Adapt Methods (TRAMs). Basic TRAMs just pass the query as it stands to episodic memory and returns any matching schemas found. However, in cases of failure, more complex TRAMs operate by applying a basic modification to the input query, querying episodic memory with the resulting new query, and returning an adaptation of any results obtained by reversing the modification applied to the original query.

A different fundamental aspect of narrative is the fact that it can be analyzed in terms of recurring structures that articulate its main ingredients into abstractions that allow its description at a higher level than simple enumerations of events. This fact has been observed by narratologists from very early studies [1, 15] with some efforts made to formalize these intuitions into stricter frameworks [37]. A number of computational implementations of story generation explicitly model narrative structure. These systems propose a top-down design implemented as attribute-grammars in which the details of the structure of a story is iteratively refined from a general definition (setting, conflict, climax and resolution, for instance) to basic events [39, 22]. These structural abstractions have been employed in the past both as means of summarization and categorization, as possible metrics of quality for narratives, and as possibly driving mechanisms for generation. Within the BRUTUS [8] system, the process of converting the resulting plot into the final output is carried out by the application of a hierarchy of grammars (story grammars, paragraph grammars, sentence grammars) that define how the story is constructed as a sequence of paragraphs which are themselves sequences of sentences.

3.10 Relating Representational Aspect with Existing Taxonomies

The different aspects that are being considered in this paper have a relation to the criteria used in the past when designing taxonomies of story generation systems. Some of the types used in these taxonomies have a correspondence with the aspects of narrative chosen as focus for computational representation. In terms of Bailey's classification, the systems he describes as based on story models map onto systems that focus on the narrative structure aspect. These would include the set of systems that Gervás et al [17] consider based on production grammars, and also the system that O'Neil [32] describes as adaptation based approaches. The systems that Bailey describes as being based on world models map well into system that focus on the simulation aspect. Niehaus' simulations or emergent systems also map onto this type of system. The systems that Gervás et al. describe as based on planning/problem solving map onto systems that focus on the causal aspect [17]. Some of the examples given by O'Neil for what he describes as search-based approaches would also map onto this set. However, O'Neil's description of search-based approaches – in particular where he describes them as exploring the set of possible sequences of actions – could also refer to systems that focus on the discourse sequence aspect.

Other types included in the taxonomies reviewed concentrate not so much on the representation being used but on the particular processes being modelled. Niehaus' category of deliberative systems is broad, and it can be seen to encompass systems that focus on either discourse sequence, causality, or narrative structure, depending on what representation the deliberation processes are applied to. In contrast with systems based on simulation, which correspond to simulations or emergent systems. Bailey's author models may also have broad application over systems that represent different aspects of narrative, as long as the systems somehow attempt to reflect processes attributed to humans. Obviously, any system that addresses the authorial aspect would fall into this category. Bailey's proposed reader models, of which none existed at the time he was writing have flourished since [3, 11, 32]

4 Discussion

Three basic issues are worthy of discussion: how existing systems show evidence of the usefulness of representing multiple aspects, what the analysis of these aspects tells us about the nature of narrative, and the relation between these aspects and the models of cognition outlined in Section 2.1.

4.1 Evidence in Support of Multi-Aspectual Representation from Existing Systems

The review presented in Section 3 has underlined the fact that many of the existing systems already attempt to model more than one narrative aspect. In fact, as more refined systems are developed, they tend to progressively extend the set of aspects of narrative that they cover.

Systems that generate a linear sequence apply different methods for selecting what action to consider next in the sequence, but they are generally chosen so that they include an implicit understanding that the statements included in the story constitute a coherent whole (with causality hopefully arising during interpretation) and lead to an interesting conclusion. Approaches that rely on representing the causal nature of narrative assume the existence of a final rendering process in which the content they produced can be exposed as an ordered set of facts, even if an intermediate representation in terms of a plan has been used to drive the construction of the plot. Systems based on planning, which are inherently causal in nature, may consider as additional information data on intentionality, or author goals. Specific modules can address thematic instantiation, or grammar based generation. Systems explicitly addressing the underlying structure of stories need to take into account a number of relations between facts, and *causality*, as a key property of narrative information, is commonly present. Inversely, causality between events builds an implicit graph that can partially define the structure of the narrative. While this bidirectional implicit influence usually exists, systems that do not explicitly employ the two aspects usually do not take advantage of the corresponding properties of both, namely the strong planning properties that explicit causality offers and the complete world construction that story structures permit.

All this is taken as evidence that consideration of more than one aspect of narrative in a generation system is considered a positive value.

4.2 The Nature of the Various Aspects in Terms of Representation

Every system models narrative creation through a certain set of data structures that help to instantiate the approach taken.

The same information may be stored in different data structures without significant loss, or a data structure can be enriched to be capable of representing additional types of information. An important conclusion of this paper is that narrative has different aspects, each of which has a different natural structure. This can be illustrated by the following examples of natural associations between aspects and data structures: the set of causal links between elements of a story is best represented as a graph, the sequence of discourse fits better into a list, and many of the narratological refinements of the three-act structure of classic tradition are best expressed as a syntactic tree.

These differences in nature can be bridged in many ways. First, more than one representation may be used, with explicit processes of mapping from one to the other added to the system. For instance, a causal account of a story is produced first and then it is linearized as discourse. Second, the way in which such data structures are actually implemented and loaded with information may lead to implicit data topologies. Many systems focusing on the narrative structure aspect often make use of attribute grammars in which attributes convey information between levels and branches of the grammar. The information contained in these attributes is used to *link* properties between characters, events or partial stories, thus connecting elements across different branches of the grammatical trees in ways more similar to how they might have been represented as a graph. Simulation-based system may employ additional models of narrative, whether at system or at character level, that may be based on some of the other aspects (planners, emotions, target plot structure...).

4.3 An Integrated Multi-Aspectual Representation Allowing Redescription

Each of the aspects of narrative described in Section 3 can be understood as a different dimension of a narrative. The review presented in Section 3 has identified existing AI technologies that provide a good model of the corresponding features. Each of these combinations of a particular representation and a particular technology can claim successful modelling of some aspect of narrative directly related to the feature that they have focused on. Constraints on the process of constructing a narrative in the sense described by Sharples can be formulated in terms of each of these dimensions.

Under this light, each of the approaches for the construction of narrative that has been attempted based on one of these dimensions is indeed a valuable model of a human ability to construct narrative, or at least a valuable model of a particular ingredient of human ability to construct narrative. Yet a complete model of the process as described by Sharples would require not just models of the construction process based on one of these dimensions, but a set of such models together with a procedure for switching across dimensions and integrating into a single draft of the narrative results from each of the models.

According to this view, each of the dimensions would correspond to a different subset of what Sharples describes as "vocabulary to describe mental processes", which beginners do not have and experts have developed over years of expertise. If one considers this point of view, the human ability to construct narratives should be considered not as a solid block of functionality, but rather as a set of posible progressive stages of development, with beginners at one end – relying on simple problem solving techniques applied to a representation based on a reduced vocabulary – and experts at the other end – possibly relying on narrative-specific techniques defined over a much broader representation vocabulary that includes many more dimensions. In that sense, systems developed along a single dimension might constitute acceptable models of beginners ability. Systems based on a restricted number of the dimensions of narrative that may be contemplated would constitute models of human ability at some point in the scale of development between beginners and experts. Sharples's description of the reflection phase could then be envisaged as progressive refinement of the initial set of constraints on the desired text. Successive constraints would be incrementally developed at the various levels: some on discourse sequence, some on character behaviour, some on emotion, some on causality.

If this were true, plausible models of human expert ability are unlikely to be achieved without representation and operation along a fair number of these dimensions of narrative. Although an intuitive step is required, such richer models may have a better chance of success at emulating the performance of human experts in terms of narrative ability.

This argument can be further explored with reference to the levels of expertise described by Karmiloff-Smith with respect to cognitive representation. Initial representations of narratives within a computational system – of the type that each system considers as output representation of a story, usually in terms of discourse sequences – would correspond to what Karmiloff-Smith calls implicit or explicit level one representations. Computational systems that model narrative at this level can be considered as static snapshots of expertise during the first phase of learning. They may evidence a basic kind of behavioural mastery – in terms of producing stories of acceptable quality. Each of the richer representations that successive systems propose as internal representation of the narrative, usually involving explicit representation of additional aspects of narrative, would correspond to explicit level two. At this level, some particular structure observable within or inferable from the previous level has been redescribed as a schema at this second level. Systems showing this type of representation can be seen as static snap shots of expertise achieved during the second phase of learning. But real expertise only comes when explicit level three is reached. In this level, a wide pool of such schemas – possibly different ones for different aspects or dimensions – are available, and they have been integrated into "a more general cognitive system". Systems at his stage would achieve the second kind of behavioural mastery, allowing representational flexibility and control that may lead to creativity.

5 Conclusions

Different aspects of narrative all have a role to play in modelling the human ability of constructing narrative. Each particular aspect is better served by a different computational technology, relying on a specific type of data structure for representation. Although technologies particular to one aspect may be extended to cope with information usually addressed by another aspect, theoretical models of cognitive process applied by humans do suggest that explicit transformations of the underlying representation – Sharples' constraints – do take place, and that these transformations known as representational redescription allow richer creative process that carry out optimal exploration of the conceptual spaces involved in a creative process. In fact, when observed in humans, this particular ability is associated with expertise in the particular task, and its absence usually observed in beginners. This suggests that efforts to model human ability to construct narrative may benefit from the exploration of models that consider a multi-aspectual representation of narrative, with explicit procedures for representational redescription across aspects, and different process – possibly of the engagement and reflection type – operating on each of these specific representations.

The set of existing systems reviewed evidences a positive trend towards an increase in the number of aspects explicitly covered by each successive system, but improvement is still possible along the lines described in the paper.

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Model of Narrative Nowness for Neurocinematic Experiments

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Abstract

Cognitive neurosciences have made significant progress in learning about brain activity in situated cognition, thanks to adopting stimuli that simulate immersion in naturalistic conditions instead of isolated artificial stimuli. In particular, the use of films in neuroscientific experiments, a paradigm often referred to as *neurocinematics*, has contributed to this success. The use of cinematic stimuli, however, has also revealed a fundamental shortcoming of neuroimaging studies: The lack of conceptual and methodological means to handle the viewers' experience of narrative events in their temporally extended contexts in the scale of full cinematic narrative, not to mention life itself. In order to give a conceptual structure to the issue of temporal contexts, we depart from the *neurophenomenological* approach to time consciousness by neurobiologist Francisco Varela, which in turn builds on Husserl's phenomenology of time. More specifically, we will discuss the experience of narrative tension, determined by backward-looking conceptualizing retention, and forward-looking anticipatory protention. Further, this conceptual structure is built into a preliminary mathematical model, simulating the dynamics of decaying and refreshing memory traces that aggregates a *retentive perspective* for each moment of nowness, which in turn may trigger anticipations for coming events, in terms of Varela and Husserl, protentions. The present tentative mathematical model is constructed using simple placeholder functions, with the intention that they would eventually be replaced by models based on empirical observations on the psychological capabilities that support narrative sensemaking. The final goal is a model that successfully simulates the way how the memory system maintains narrative tension beyond the transient nowness window, and thereby allows mappings to observed brain activity with a rich temporal system of narrative contexts.

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1 Neurocinematics

Naturalistic neurosciences aim at studying human cognitive functions in conditions that resemble real-life situations. To apply films as the source of life-like stimuli for brain imaging experiments in particular has been referred to as *neurocinematics* [11]. From the methodological point of view, films, despite their apparent complexity, are highly controllable because every aspect of narrative flow has been designed to accomplish particular effects by

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means of the established cinematographic methods. In turn, the viewers expect the narrative flow to be structured to guide their attention and anticipation.

Neurocinematic studies have revealed the similarity of brain responses across viewers when watching the same film [12, 16]. They have also identified distinct brain dynamics in subjects viewing, for instance, faces of other people or landscapes [12, 27], global or local movement [3], or aspects of social behavior [23, 28]. Another study seems to suggest that narrative tension makes a difference. The fMRI experiment by Hasson and colleagues showed significant intersubjective correlation between the brain responses of viewers of a Hitchcock film, but this did not hold for those watching a random surveillance video footage [11]. This indicates that the similarity of brain behavior between viewers is likely due to the way their attention is trapped, guided, and tricked by the narrative design that is, in our interpretation, a system of temporal contexts.

Indeed, filmmaking relies on the mastery of manipulating the viewer's attention in time. The neuroscientific observations of film-viewing made so far make it compelling to look into the factors contributing to narrative cognition in the full temporal scope of films, which, broadly seen, may correspond to the temporal situatedness of humans in life. However, as has been pointed out, the mere comparison of content annotation of features present at a given moment with the synchronized brain responses may not alone provide a sufficient basis for naturalistic neurosciences to understand higher levels of cognitive functions [12, 16]. This will require new means of taking into account a broader temporal frame of narrative contexts. In our view, neuroscientific studies that neglect the viewer's temporal situatedness with respect to continuous narrative just fall short of meeting the attribute 'naturalistic'. It is important to emphasize that we do not count on the possibility of solving the context-dependency on the level of annotation. Instead we trust on that the contextualization is to a great extent an idiosyncratic process and dynamically dependent on one's previous experiences, which, yet, is to a great extent intersubjectively shared between different people due to the similar biologically and socio-cultural conditioned situatedness.

2 Time and narration in neurocinematics

Due to the rapid development of data collection and analysis methods recent brain research has in large part overcome the technical issues related to the massive amounts of brain data accumulating from long sequences of stimuli, such as films. The so called *free-viewing* method allows unconstrained viewing of entire films in fMRI [12, 2]. In such settings, similar to everyday movie viewing experience, all previous events condition the experience of nowness and the anticipation of the coming events along the narrative. Consequently, the key question for neurocinematics is, how to relate the measured brain activation to the viewer's experience of making sense of the story.

Annotation of content is the prerequisite of interpreting brain activity against cinematic content [31]. Several overlapping methods are already in use within distinct fields, e.g. in automated video analysis, discourse analysis, dramaturgy, psychology, or sociology [4, 41, 30, 40]. This is, however, a broad field of methodological development that falls outside of the present topic. For our discussion it suffices to assume that meaningful events in the footage are annotated and time-synchronized so that they can be related with the brain activity that they evoke.

The point we wish to make is that time-synchronized annotation alone is not enough to describe the viewer's consciousness of the narrative sequence through time. We propose that another layer of representing the narrative is needed to relate it to the brain activity.

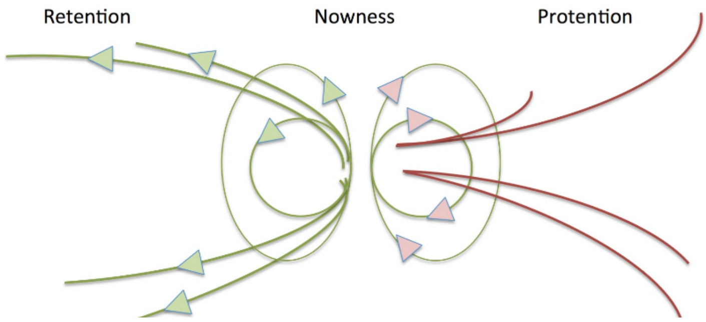

Figure 1 The multi-layered structure of nowness constituted by 'retention' and 'protention'. In the image, narrative time can be seen to flow horizontally from left to right. Between the dynamical loops of retention and protention emerges the experience of nowness. The arrows indicate the experiential 'knowledge' constituted by the memory traces of the past (retention) and simultaneous anticipation of the future (protention). No arrows are marked to the protentional 'threads' (red lines) as this is yet to unfold. Originally drafted to describe the time consciousness as 'nowness' in general, the image is here adapted from Varela ("The Specious Present", 1999, p. 303) to describe the experiential moment of 'narrative nowness' in particular.

The recent findings of *temporal receptive windows* in the brain may guide the mapping of phenomenological, neural and behavioral nowness into narrative structures on different time scales. For example, a cortical hierarchy related to varying scales of temporal narrative coherence was detected by Lerner and colleagues in a functional neuroimaging study that looked at intersubject correlations across people who were engaged in a) 'backward story', b) 'scrambled word', c) 'scrambled sentence', d) 'scrambled paragraph', and e) intact 'forward story' [25]. The studies suggest a hierarchy of frequency bands in brain signals, typically with highest frequencies in the posterior and lowest in the most anterior parts of the brain [25, 13, 22]. According to Hasson and colleagues, the higher cognitive regions, such as posterior lateral sulcus, temporal parietal junction, and frontal eye field, responded to information accumulated over longer durations (∼36s) than, for example, superior temporal sulcus and precuneus (∼12s) [13]. This leads to the reasoning that perhaps the measured length of the temporal receptive windows in the brain corresponds to the size and complexity of spatial receptive fields (e.g., visual cortex) on one hand, and, on the other, to the level of abstraction of neural representations [13, 15]. The direct implication of these findings is that temporal situatedness is to be conceived of in terms of multiple layers. In order to accommodate this, we will first elaborate a preliminary conceptual model of narrative time to be followed by a more formal mathematical model.

3 Conceptualizing time consciousness

Varela's neurophenomenological interpretation of Husserl's views on temporality assumes moments of nowness embedded in broader temporal contexts in terms of *retention* and *protention* [37, 36, 14]. *Retention* refers to the temporally backwards-extended present, consisting of a tail of past events, retained on multiple levels of gradually decaying memory traces, serving as contexts that determine the interpretation of nowness. *Protention*, in turn, refers to the anticipation of the next moment implied by nowness. (Fig. 1) The experience of narrative tension can be said to consist of both retention and protention dynamics.

In terms of this conceptualization, we propose a dynamic model of narrative nowness that serves neurocinematic studies beyond the present and ideally allows mappings between retention and protention onto observed brain activity. Varela points out three aspects that are intertwined in the neurophenomenological study of time consciousness: "(1) the neurobiological basis, (2) the formal descriptive tools mostly derived from nonlinear dynamics, and (3) the nature of lived temporal experience studied under reduction"[1]. The proposed model allows comprehension of *nowness* as simultaneously passing past with the still reachable memory of the gradually distancing past (retention), as well as the anticipation of gradually approaching future events (protention). A spatial metaphor may help to depict the gradually 'distancing' or 'approaching' nature of the experiential elements of nowness. In James's terms, nowness can be said to have a focus, margin, and a fringe [18]. The duration of nowness can be intuitively defined in terms of the natural limits of ongoing action, e.g., gestures or actions. This draws from the studies suggesting that cognitive segmentation of narratives into meaningful sequences and events is seemingly an in-built cognitive mechanism [43, 32]. The corresponding instrumental notion of *protonarrative*[2] relates to the phenomenological idea of nowness, referring to the shortest possible meaningful event. For example, the moment when someone is rejected by another person exemplifies a protonarrative within the duration of a few seconds. This unit, may serve as a preliminary heuristic for the segmentation of film content into events, such as discussed by Zacks and colleagues [42], and thereby as a pointer to the neural phenomena related to the sense of nowness.

Quite obviously, the order of introducing narrative elements constitutes the foundation of a narrative. What has happened earlier will define the interpretation of every following moment of nowness. We assume that once introduced, each meaningful event i establishes a *narrative dimension*, and everything that takes place after it can be described in relation to dimension i with reference to the corresponding *narrative coordinate dimension* x_i. The dimensions altogether define a high-dimensional *narrative ontospace* [29], the abstract stage representing all features whose presence can be meaningful in the story. The ontospace [21] is very high-dimensional altogether, but the perspective, as we define it, limits the dimensionality of the momentarily significant space (representational space). There is no need to assume orthogonality of the dimensions.

Further, we assume that the prominences of each of the dimensions altogether constitute a set of weights, one for each. This set, termed the retentive perspective, determines to what extent each narrative dimension is taken into account in the experience of nowness by the viewer, following the spatial conceptualization of Pugliese and colleagues [29]. A narrative perspective can be conceived of as a vector, with weights assigned to each dimension. Based on previous research of the memory [5, 33, 20, 39], decay functions (forgetting curves) can be modeled with power-law (i.e., $\sim t^{-w}$) and exponential (i.e., $\sim e^{-wt}$) functions, with specific decay weights ($w > 0$) for narrative dimensions. The *narrative perspective* refers to automated, predominantly unconscious moment-to-moment prioritizations among the dimensions set by the individual movie viewer's memory and attention, determining the influence of each in the experience at each transient moment. Another factor is the one of context-refreshing associations induced by the unfolding story, constituting a feedback loop that regulates the way the retentive memory traces influence the interpretation of nowness.

The experience of nowness, as described above, while being based on the retentive perspective, is dynamically coupled to some *protentive function*, triggering anticipation of

[1] Varela "The Specious Present", p. 305.
[2] The notion of protonarrative applied in neuroscience by Pia Tikka in 2010; See also Philip Lewin's essay "The Ethical Self in the Play of Affect and Voice," at the Conference on After Postmodernism, University of Chicago, November 14-16, 1997, `www.focusing.org/apm_papers/Lewin.html`.

coming events. It is, however, beyond the proposed model to predict what the anticipated events may be. It may suffice here to assume that anticipations involve the entire cognitive-perceptual and experiential apparatus, with its evolution-hard-wired elements, such as emotions, logic inference, as well as learned and culturally assimilated associations.

The implicit assumption behind the model is that among the functional neural networks that are active at the moment of nowness are those that were also triggered at previous stages, when particular aspects of the story were originally introduced, thus constituting the narrative context against which it is now interpreted. This assumption is similar to Damasio's idea of somatic markers, where 'marker' signals "influence the processes of response to stimuli, at multiple levels of operation, some of which occur overtly (consciously, 'in mind') and some of which occur covertly (non-consciously, in a non-minded manner)"[8]. In other words, narrative nowness involves continuous holistic updating of one's situatedness that aims at predictive decision-making related to protentive landscape. The ideal model, for the time being considered as a conceptual model, should eventually be modified to match with empirically observed memory and attention functions. Provided a level of validity with respect to these aspects of psychology, the model should be able to generate predictions for brain responses to cinematic events embedded in their full narrative contexts.

4 Formal framework of the Narrative Nowness model

We now propose a mathematical framework for the nowness model, which aims to catch explanatory aspects of time-dependent dynamics of activation, decay and interference of narrative weights (x_i's). The model is inspired and based on studies on memory and text processing [1, 38, 19, 5, 33, 26, 39, 17, 34, 24] and the model proposed by Cadez and colleagues [7, 6], where multiple memory traces were considered. Narrative weights associated with narrative dimensions are considered mainly as representations of episodic memories with relatively short durations (up to hours rather than days). Narrative weights are assumed to evolve continuously in time. We also assume, for the sake of simplicity, that the structure of the narrative is relatively linear and classical (i.e., exposition, climax, resolution). Let us assume that there are N real-valued narrative dimensions (x_i's). Weights are assumed to follow the dynamical equation

$$\frac{dx_i(t)}{dt} = F_i^D(t) + F_i^S(t) + \sum_{\substack{j=1 \\ j\neq i}}^{N} F_{i,j}^I(t) + F_i^P(t) + \varepsilon_i(t) \tag{1}$$

where $i=1, 2, \ldots, N$. At each timepoint, the set of weights x_i define the *narrative perspective*. Real-valued functions are as follows: F^D defines the decay, F^S defines the activation source, F^I defines the narrative interactions, F^P defines the protention mechanism, and ε is the error. Error function ε covers any model inaccuracies and randomness (noise) and it can be expected to become significant especially for complex and rich stimuli, such as movies. In the presence of random noise, the dynamics becomes stochastic. Protentive functions F^P contain high-level abstract cognitive processing of the narrative information and generally have long temporal memory. We assume that the narrative tension, consisting of the interplay of retention and protention, is essential for well constructed narratives, where events are related to each other both in time and between narrative dimensions. Therefore the protention creates a kind of anticipatory mechanism of the future events.

In general, solutions x_i are not expected to be unique with respect to functions F; there might be more than one stimulus that produce the same solution. All functions in Eq. (1)

are assumed to have nonlinear time-dependent forms that - without further approximations - cannot be reduced into elementary functions. Time-dependency (i.e., non-stationarity) is important, because narratives develop in time.

We now describe a simplified version of Eq. (1) using linearization and elementary functions. For each narrative dimension, we assume that there is a set of instantaneous narrative events at times $0 < T_i(1) < T_i(2) < \cdots < \infty$ with corresponding impulse weights $0 < I_i(k) < \infty$ for all $k = 1, \ldots, |T_i|$. Impulses can be defined using the delta function $\delta(t)$. After the impulse has occurred, the corresponding weight decreases exponentially with the decay rate $d_i > 0$, which are gradually reduced with a factor $r_i \in (0, 1]$ after each impulse. Factor r_i simulates the memory reinforcement effect due to repetitions. While power-law decay may be closer to empirical data (see discussion in Refs. [5, 33, 20]), exponential function is easier to implement due to linear derivative. Narrative dimensions are coupled to each other linearly with coefficients $C \in \Re^{N\times N}$, where negative (positive) values indicate reinforcement (interference) between two narrative pairs. Interference increases the decay rate, which leads to faster decrease of the narrative weight. In a simple approximation, the noise term ε_i takes a Gaussian form $\alpha(t)dB(t)$, where $\alpha(t) \geq 0$ and $dB(t)$ is the Wiener process with $B(t + \triangle t) - B(t) \sim \sqrt{\triangle t}\mathcal{N}(0, 1)$ [35]. As the noise should activate only after the first impulse (i.e., introduction of the narrative dimension), we set $\alpha_i(t) := \hat{\alpha}_i(t)H(t - T_i(1))$, where H is the Heaviside step function and $\hat{\alpha}_i(t)$ is the noise coefficient. The noise is assumed to be uncorrelated between narrative dimensions. Since the protention functions F_i^P's depend on the narrative (stimulus), they cannot be simplified. However, depending on the specific narrative and by choosing the narrative dimensions carefully (e.g., via basis transformations), it could be possible to separate the dimensions in *retention-weighted* and *protention-weighted* ones. For retention-weighted dimensions, we can assume that the effect of impulses, decay and interactions overcome the protention effects (e.g., long memory) and set $F^P \approx 0$. Similarly for protention weighted dimensions, we may assume that F^P dominates the dynamics. With above assumptions, the time-evolution of retentive weighted x_i is given by

$$\frac{dx_i(t)}{dt} = -x_i(t)\left(d_i^0 r_i^{|\{k:T_i(k)<t\}|} + \sum_{\substack{j=1\\ j\neq i}}^{N} C_{i,j}(t)x_j(t)\right) + \sum_{k=1}^{|T_i|} I_i(t)\delta(t - T_i(k)) + \alpha_i(t)dB(t) \quad (2)$$

If proper scaling of parameters is used, absorbing boundary conditions $x_i(t) \in [0, 1]$ can be used. At minimum, one must define parameters d_i^0 (initial decay rate), impulse timepoints T_i and interaction matrix C, while the remaining parameters are approximated by other means. If the protention effects are of interest and/or they cannot be separated, functions F^P must be provided and included in the model. Despite its simplicity, Eq. (2) already allows complicated non-linear dynamics to emerge. Numerical solutions are straightforward to compute and one can apply Monte Carlo approach to study the model.

Finally, let us run a numerical simulation to demonstrate Eq. (2) for N=5 with four retention ($i = 1, \ldots, 4$) and one protention-weighted ($i = 5$) dimensions with an artificial stimulus of duration 2h (7200s). For the initial decay rates, we set $d^0 = [3E{-}4, 4E{-}4, 5E{-}4, 6E{-}4]$. Value $\sim$4.3$E{-}4$ corresponds to the classical result by Herman Ebbinghaus (1885) of forgetting $\sim$40% in 20min. Matrix C is symmetric with $C_{1,2} = -1E{-}3$, $C_{1,3} = 2E{-}3$, $C_{1,4} = 4E{-}3$ and $2E{-}3$ for the remaining three. Impulse powers are set to $I = [1, 0.75, 1, 0.90]$. Noise coefficient $\hat{\alpha} = 1.5E{-}3$ and repeat factor $r = 0.80$ are set equal for all $i = 1, \ldots, 4$. Impulses are picked at random with total counts $10, 13, 7$ and 12. For the protention-weighted dimension, we set $x_5(t) = \int_{\max(0,t-600s)}^{t} ds x_1(s)x_2(s)x_3(s)/\min(t, 600s)$, i.e., a product function with 10min memory, from which F^P can be computed. Initially at $t = 0$ all x_i are set to zero. Numerical solution with the time discretization 0.5s is depicted in Fig. 2.

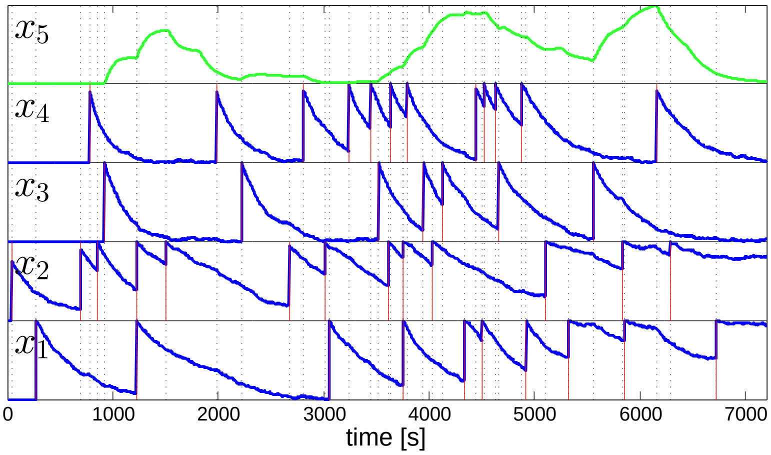

Figure 2 Numerical solution of equation set (2) with N=5 narrative dimensions and an artificial 2h stimulus. The speculative protention-weighted dimension x_5 (green line) depends on retention-weighted dimensions $x_{1,\ldots,4}$ (blue lines). Vertical red lines indicate stimulus impulses.

5 Discussion

So far, naturalistic neuroscientific studies have revealed important relations between the audiovisual content and the corresponding brain activity across spectators. However, this has been feasible only within isolated time frames, without relating contextual conditions constituted by the earlier narrative events and the anticipations they trigger in the viewers' experience in time scales natural to film viewing, not to mention life itself. We envision that the narrative nowness model will open new ways for analysing and interpreting the results of neurocinematic experiments, which assume time consciousness within the duration of entire movies. In addition, the concept of narrative perspective, associated with nowness, can in principle accommodate even broader life contexts and other individual determinants of experience, such as engagement in a film culture, or cross-references between movies. Because of this complexity, it is meaningless to make more detailed assumptions of the model at this hypothetical phase.

We acknowledge the similarity between the paradigms of sentence processing and narrative processing as both require integration and memorization of previous events (i.e., words, sentences and narrative elements; see [26, 17, 34]). However, the time-scale of sentence processing is much shorter (seconds), which is not enough to generate long-duration dynamics required by protention mechanism. Existing computational models in linguistics are typically discrete (see, e.g., [10, 9, 24]) rather than occurring in continuous time domain. There is a need for a model that allows studying narrative comprehension closer to the signal processing perspective.

A mathematical framework for a nowness model was presented (Eq. (1)) with a simplified version (Eq. (2)) allowing numerical experiments. This model accommodates a number of aspects that are assumed to be relevant in narrative comprehension, such as increasing, decreasing and interacting of narrative weights. Although it is generally impossible to reduce high-level cognitive processes into few equations, the model is (another) step towards understanding narratives via computational methods.

We are fully aware that the experimental verification of the proposed model is a significant challenge at this stage, since it is not directly evident which values in the empirical observations would correspond to narrative weights (x_i). With techniques, such as MEG and fMRI, the possible information of the weights is expected to be hidden within measured multivariate signals. These techniques also have limitations of their own, such as long-tailed autocorrelation in the fMRI's BOLD signal. On the other hand, behavioral measurements require active participation of the subjects, which can interfere with the narrative comprehension, especially when time-dependent data is needed. One must also define the numerical values of narrative weights, e,g., they might be percentages of correctly remembered details or recall time of narrative elements. The model does not specify any rules how to define protention functions (F^P), as these are fundamentally linked to building narratives themselves. However, it might be easier to solve an inverse problem: Estimate F^P's while given (protention weighted) solutions x_i. Indeed, it is typically certain protention functions that are targeted when designing the story arc of the narrative (e.g., tension, fear, arousal), which lead to selection and timing of individual narrative events and cues.

While the proposed nowness model should be regarded as the broad hypothesis that the experience of nowness can be modeled and mapped to its neural epiphenomena, drawing inspiration from the heritage of Husserl and Varela, it may also be seen to imply a new paradigm of research. The model can contribute to the analysis of time- and context-dependency of narratives and facilitate bridging the gap between the real-life situations and restricted neuroimaging conditions on one hand. On the other, it will allow generalisations from cinematic situations to those of everyday life thus supporting the relevance of neurocinematics to naturalistic neuroscience in general. After all, the issue of time consciousness is not unique to cinema. All cognitive functions are associated with their temporal situatedness within the world's narratives, as reflected by one's unique experience. The potential of conducting experiments with narratively significant contexts increases also the value of the neurocinematic studies for the cinematic arts, and more generally, all narrative arts.

6 Conclusions

The neurocinematic paradigm has revealed the limits of the so called naturalistic neuroscience with regard to interpreting brain activity elicited by narrative events embedded in temporal contexts beyond the immediately present. This points out the need for a method of interpreting neural activity elicited by events in their broad narrative contexts in the scale of full-length films. Following Varela and Husserl's phenomenology of time, we divide the assumed narrative tension at a particular moment of nowness into the backward and forward looking components of retention and protention, respectively. We have proposed a preliminary model of how memory traces of past events in a narrative sequence may dynamically aggregate a retentive perspective that conditions the experience of each moment of nowness. The model is purely mathematical, constructed using simple placeholder functions that can later be replaced by empirically founded functions capable of framing a refined understanding of how narrative memory traces retain and decay in the memory. Although we postulate that the experience of nowness in itself implies an anticipation for future events and reserve it a place, modelling this protentive aspect remains as another challenge beyond the present.

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Mindreading, Privileged Access and Understanding Narratives

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Abstract

In this paper we first offer a task analysis of the false belief test including the bidirectional relationship between mindreading and language. Following this we present our theory concerning Quinian bootstrapping of the meaning of mental state terms and relate it to the task-analytic framework. Finally we present an experiment on ascribing privileged access through minimal narratives which is intended to serve as a test of our theory.

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1 Introduction

In this paper we present a theory concerning the acquisition of mental state terms and their usage in the explanation and prediction of behaviour. In order to see the broader context of our theory first we discuss the task analysis of the famous false belief test. This is important because one can interpret the passing of this verbal test as a manifestation of the possession of the mental term of belief. As we are interested in the acquisition of mental terms, in our task analysis we will focus on the bidirectional relationship between mindreading and language. Following this we present our theory of Quinian bootstrapping of the semantics of mental state words. We will see that the third stage of this bootstrapping process is the formation of a so-called folk functionalist theory of mental state terms. We describe an experiment that we did in order to examine the formation this folk functionalist theory. This experiment addressed the understanding of the notion of privileged access in children. We were curious whether children can explain and predict the behaviour of protagonists in minimal narratives; to this end we examined the usage of mental state terms in our subjects' interpretation of a character's behaviour in those narratives.

2 The task analysis of the false belief test

During the last thirty five years there has been an explosion of research into the naïve theory of mind (ToM) of primates, children and adults. At present, research in this area is conducted under various different labels within the cognitive sciences such as naïve psychology,

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intuitive psychology, everyday psychology, common sense psychology, folk psychology, belief-desire psychology, natural psychology, interpretation, mentalization, metarepresentation and mindreading. In the present paper, we shall use these terms as roughly synonyms. By theory of mind we mean the basic ability to attribute or impute mental states (e.g., beliefs, desires, intentions, thoughts, emotions and so on) to ourselves and others in order to explain, predict, interpret and influence the behaviour.

In everyday life there are a lot of occasions where we read the minds of other people around us. One such situation is the classic false belief scenario. The famous false belief task was suggested by philosophers (e.g., [12]) in response to [17] question concerning the possibility of the chimpanzee's theory of mind. At that time, philosophers thought that the real criterion of theory of mind is the case when the organism can ascribe a mental state to the other which is different from its own. This is the situation in the classic change of location false belief task [24]. In this task, children watch the following scenario: Maxi puts his chocolate in location A in the kitchen and then leaves the scene. In his absence, his mother removes the chocolate from location A and puts it in location B. Then Maxi returns and the child is asked where he will search for his chocolate. The basic finding is that three-year-olds say that Maxi will look for his chocolate in the new B place while only four-year-olds can correctly indicate location A in their verbal responses.

Why do three-year-olds fail on this task and what are the cognitive requirements of passing this test at four years of age? In other words, what kind of task analysis can we provide for the success on this false belief test? At present, there are nearly twenty different cognitive explanations for these questions and the most important ones are listed below.

1. According to Leslie (e.g., [39]), humans have an innate theory of mind module which manifests itself in pretend play between 18-and 24-month-of-age. In Leslie's view, this innate mindreading module is not sufficient to pass the famous false belief test because the latter also requires the so-called *selection processor* which is responsible for inhibiting the reality-based response (i.e., that the chocolate is in location B). So three-year-olds have an intact theory of mind module but their selection processor does not yet work appropriately. The opposite is true in the case of children with autism: these children do not have a mindreading module but they possess a selection processor which is at work when these children pass the false photograph test. So children with autism can represent public, external representation such as an outdated photograph and their deficit is specifically with representing mental states. In other words, they have a domain-specific deficit.
2. According to Perner [29], passing the false belief test requires metarepresentational ability on the child's part. Perner explicitly commits himself to Fodor's Representational Theory of Mind [3] which simply holds that mental states are representational states. So when the child forms a representation about a representational state such as a belief, she constructs a metarepresentation. This is not enough, however, for managing on false belief tasks. Following Frege, Perner argues that in order to pass the false belief task the child needs to understand the distinction between the reference and sense of a representation. In his task analysis the four-year-old child understands that the reference of Maxi's representation is that the chocolate is in location B while the sense of his mental representation is that the chocolate is in location A. And the child believes that Maxi will act in accordance with his sense of representation.1. According to Leslie (e.g., [39]), humans have an innate theory of mind module which manifests itself in pretend play between 18-and 24-month-of-age. In Leslie's view, this innate mindreading module is not sufficient to pass the famous false belief test because the latter also requires the so-called selection processor which is

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3. Apperly [10] argues that the central feature of the false belief test is perspective-taking. In order to pass this test the child needs to adopt the perspective of Maxi and predict the searching behaviour on this basis. In other words, the child must overcome her egocentric bias that the chocolate is in location B.
4. According to Gopnik and Wellman [8], the false belief test requires the concept of belief. On their view, concepts are embedded within intuitive theories. A crucial feature of cognitive development is that these naïve theories change. In fact, this whole research field is called theory of mind which shows the influence of this particular, so-called theory-theory position.
5. A further analysis of the false belief test builds on the notion of executive functions. 'Executive function' is an umbrella term covering, among other things, the following notions: the inhibition of pre-potent responses, planning, the temporal organisation and monitoring of actions, sequencing behaviour, sustained attention, working memory, impulse control, etc. Within the false belief test the executive component is the inhibition of the reality-based response (the chocolate is in location B). This executive element is similar to the above discussed task of the selection processor.
6. It is important to realise that the false belief test eventually is a kind of narrative. So it should come as no surprise that if we highlight the story component of the false belief scenario then even three-year-olds are able to pass the task [11].
7. According to the task analysis of Frye, Zelazzo and Palfai [13], the false belief task can be broken down to understanding of conditionals. If Maxi wants to find his chocolate then he should search at location A. Indeed, these authors report significant correlations between the understanding of conditional statements and passing the false belief test.
8. De Villiers and de Villiers (e.g., [22]) provided experimental evidence to support the thesis that the acquisition of the syntax of the so-called complement-taking predicates is a cognitive prerequisite for passing the false belief test. Deaf children whose parents are not using any sign language are delayed at the false belief test.
9. According to Riggs, Peterson, Robinson, and Mitchell [30], there is a strong correlation between passing the false belief test and understanding of counterfactual statements. Within the false belief scenario the real situation is that the chocolate is in location B and the case that Maxi should look for location A is counterfactual with respect to this actual case.
10. We have seen above that in order to pass the false belief task children must possess the concept of belief. Where does this concept come from? According to Paul Harris [35], the child needs to participate in conversations and she can construct the notion of belief from these dialogues. So the experience in participating in conversations is a necessary precondition of passing the false belief test.
11. Both Paul Harris and Alvin Goldman [27] are committed to the so-called simulation theory of mindreading. According to them, the child can pass the false belief test via a kind of mental simulation in which she uses her own mind introspectively to predict the

protagonist's behaviour. In doing so, the child can rely on her imaginary identification with the protagonist.

12. The specific role of introspection in passing the false belief test is not restricted to simulation theory. Kuhn [15] also argues that self-observation plays a decisive role in the accomplishment of this task. On this view, the child forms the concept of belief via introspection.

13. In Fonagy's (e.g., [46]) view, there is a strong correlation between the security of attachment as measured by the strange situation in infancy and the age at which children can pass the false belief test. In fact, secure children can pass this task earlier than their insecure peers.

14. Astington [59] provides a social constructivist account of mindreading which is necessary for passing the false belief task. On this view, the concept of false belief emerges first at the interpersonal level and only later does it become interiorised into the individual's mind.

15. According to Fodor [4], folk psychology is innate and the basic inborn mindreading apparatus is present in the competence of the three-year-old child but at the same time she has performance limitations such as different cognitive heuristics which mask this competence. Moreover, Fodor suggests various hypothetical experiments in order to confirm his view.

16. There exists an explanation according to which the false belief test is a kind of meta-memory task. Notice, that in order to pass this task the child must attribute a memory to Maxi (i.e., He remembers where he put his chocolate at the beginning.)

17. A further explanation of the success on this test requires the notion of intention. The argument being simply that Maxi wants to find his chocolate. So this task involves the ascription of intention to the protagonist.

18. Dan Sperber (e.g., Sperber et al. [20]) argues that the false belief test can be approached as a task of epistemic vigilance. On this view, it is an important cognitive developmental achievement when the child gives up her basic trust that played an important role in early communication and begins to take into account the possibility of misleading information such as a lie or error.

19. Finally, Helming, Strickland and Jacob [32] argue that the classic false belief task is a normative task, that is, three-years-olds interpret the test question as "Where should Maxi look for his chocolate?" And the correct answer to this question is location B (since that is the actual location, and arguably it is a norm that one should look for something where it actually is).

By this quick review of positions we intend to illustrate why Bloom and German [43] are right when they suggest to abandon the false belief task as a test of theory of mind. On the one hand, the classic false belief test contain elements that are not specific to theory of mind (e.g., executive functions), and on the other, there are important mindreading developments before passing this task (e.g., understanding visual perspective). These different explanations are summarised in Table 1.

We collected the cognitive explanations of the verbal false belief task. Since 2005 we have a growing body of experimental evidence concerning the infants' ability to attribute false beliefs to others (e.g., Kovacs et al. [1]; Onishi and Baillargeon [34]) as it is demonstrated in various non-verbal tasks. These violations-of-expectations experiments are subject to different interpretations. One of them is that infants have an implicit theory of mind. Indeed, Onishi and Baillargeon argue that 15-month-old infants have a representational understanding of

Table 1 Cognitive explanations of the false belief test

Authors	Explanations	Evidence
Leslie	Innate theory of mind module	Theoretical and experimental
Perner	Metarepresentation	Conceptual and experimental
Apperly	Perspective-taking	Experimental
Gopnik and Wellman	Conceptual change	Experimental
Russell	Executive functions	Experimental
Lewis	Narratives	Experimental
Kuhn	Introspection	Theoretical
Frye, Zelazzo and Palfai	Understanding of conditionals	Experimental and correlational
De Villiers	The syntax of complement-taking predicates	Experimental
Harris	Conversations	Observations
Riggs	Understanding of counterfactuals	Experimental and observational
Fonagy	Secure attachment	Experimental and observational
Goldman	Simulation and imaginary identification with the protagonist	Philosophical and experimental
Astington	Social constructivism	Experimental
Fodor	Cognitive heuristics	Hypothetical experiments
	Metamemory	Conceptual
	Attribution of intention to the protagonist	Conceptual
Sperber	Epistemic vigilance	Experimental
Jacob	The test as a normative task	Conceptual

mind. Ruffman and Perner [57] provide an alternative, strictly behavioural explanation to this rich interpretation.

At present there are various attempts to explain the existing gap between early mindreading and later success on the verbal false belief task. For instance, one such attempt is Alan Leslie's theory of an innate mindreading module and his selection processor discussed above.

3 The relationship between social cognition and language

What is the connection between mindreading and language? The relationship between social cognition and language is in the focus of several researchers (see e.g., Astington and Baird, [60]). One view is that certain mindreading abilities are the cognitive prerequisites for acquiring language. Below, we offer a rough summary of these different theory of mind preconditions and the various aspects of language being explained by them.

1. According to Bloom [42], understanding of the speakers' referential intention is necessary for word learning. To put this into a broader perspective we can say that the acquisition of the mental lexicon is dependent upon one's theory of mind.
2. Baldwin (Baldwin and Moses, [2]) demonstrated experimentally that older infants can take into account the other's direction of gaze when they learn a new word. This means

that in a situation where there are more new objects present infants will attach the heard new label to that particular object to which the speaker paid attention rather than that the one they themselves looked at. So again learning a new word requires theory of mind ability; in this case the understanding of attention.

3. Tomasello [19] argues that the so-called nine-month-olds' revolution in understanding intentions is a cognitive prerequisite for language acquisition. At nine-month-of-age infants begin to demonstrate volitional behaviour and this is the base on which they can ascribe intentions to other people around them. Theoretically speaking, this is a kind of mental simulation by which the infants understand others.
4. Beckwith [56] claims that the emergence of the concept of other minds is a precondition for the formation of the so-called Experiencer thematic role. Thematic roles (such as Agent, Theme, Experiencer, Goal, etc.) are the semantic labels for various arguments in the predicate-arguments linguistic theories. In particular, the so-called psychological verbs (such as fear, love, hate) take the Experiencer role as one of their arguments.
5. Hamvas [21] presented experimental evidence showing significant correlation between passing the false belief test and detecting the violation of Gricean conversational maxims. So we can argue that the concept of false belief is required for certain pragmatic abilities.
6. Similarly, Happé [26] showed that the notion of false belief is necessary for understanding metaphors. In fact, she experimentally tested the basic tenets of Relevance theory (Sperber and Wilson, [18]) arguing for the mindreading basis of conversational pragmatics (see also Kiss, [53]).
7. Győri [38] also presented experimental evidence for his view that mindreading is a prerequisite for understanding irony.

These different positions are summarised in Table 2. But the above list is only one side of the coin. The other side is that many linguistic factors play a role in the emergence of theory of mind. Below, we summarize these linguistic prerequisites and the elements of mindreading that are explained by them. So we can conclude that the connection between mindreading as a micro-level phenomenon and language (as a macro-level phenomenon) is a bidirectional one.

1. Astington and Baird [60] collect various papers which all claim that language matters for theory of mind. Their book came out in the same year when Onishi and Baillargeon [34] reported their experimental findings concerning the infants' implicit theory of mind discussed above. So, of course this book cannot address the issue of the existence of a preverbal mindreading competence.
2. Within the task analysis of the well-known false belief test we saw the strong and provocative proposal by de Villiers and de Villiers [22] according to which the syntax of complementation is necessary for passing this test. So they view syntax as a linguistic precondition of mature theory of mind.
3. We have also discussed Harris's [35] theory that claims that conversations are inevitable for the mental construction of belief. Here again we can see that some kind of linguistic practice is responsible for certain social cognitive achievements.
4. O'Neill [33] argues that the linguistic given/new distinction is mandatory for the development of certain pragmatic skills. But it should be noted that since the pioneering work of Paul Grice pragmatics and mindreading are so closely connected that one can hardly disentangle these two basic competences.
5. In a relatively early work, Astington [58] dealt with the connection between narratives and the child's developing theory of mind. Of course, it is needless to say that the ascription of mental states to the protagonist is a central feature of all stories.

Table 2 Social cognitive prerequisites for language

Authors	**Special mindreading ability**	**What aspect of language is explained**
Bloom	Understanding referential intention	Word learning
Baldwin	Gaze-following	Acquisition of the lexicon
Tomasello	Nine-month-olds' revolution in understanding intentions	Word learning
Beckwith	The emergence of the concept of other minds	Formation of the Experiencer thematic role
Kiss Sz.	Passing the false belief test	Relevance theory
Hamvas E.	Passing the false belief test	Grice: Conversational maxims
Happe	Passing the false belief test	Understanding metaphors
Győri M.	General theory of mind	Understanding irony

Table 3 Linguistic prerequisites for social cognition.

Author	**Linguistic prerequisites**	**What aspect of mindreading is explained**
Astington and Baird	Language in general	Theory of mind
DeVilliers	Syntax	Passing the verbal false belief test
Harris	Conversations	The emergence of the concept of belief
O'Neill	The given/new distinction	Pragmatics
Astington	Narratives	Mindreading stories
Kiss	Lexical semantics	The meaning variance of mental terms

6. Kiss [54] describes the acquisition of the meaning of mental terms within the so-called theory of mind research field. (See also the next section of the present paper for more details on this.)

These views are presented in Table 3. In this section we looked at answers to the following general question: What is the exact role of language in the formation of theory of mind? As our primary interest in this paper is the acquisition of mental state terms, we would like to offer another five possible theoretical roles for language in ToM.

1. First, one could suggest that language in general, and the mental terms in particular, are merely labels for our independently existing concepts (Fodor, [5], [6]).
2. Second, we may assume that language is an "invitation to form categories", thereby playing a facilitatory role
3. Third, R. Mitchell ([48], p. 41) says in the spirit of Wittgenstein ([36], par. 384): "In a sense, language creates mental states: "You learned the concept "'pain' when you learned language" Note however, that in this quotation Wittgenstein refers to concepts, but Mitchell is concerned with mental states in general.
4. Fourth, language may be taken as a replacement of expressive behaviour.
5. Fifth, language can be understood as a medium for representing mental states.

4 Quinian bootstrapping of mental terms

Now we would like to explore the role of Quinian bootstrapping in the acquisition of the meanings of mental terms such as “happy”, “think”, “believe” etc. Let us briefly introduce Quinian bootstrapping as developed by Carey ([50], [51]). From Carey’s analysis we pick out the importance of a placeholder structure. The placeholder structure consists of symbols whose meanings are initially determined in relation to each other. In this structure, many symbols are connected to each other and these connections are represented in long-term memory. At the beginning of the bootstrapping process the symbols have no meaning but later the so-called modelling processes give meaning to these symbols. According to Carey, these modelling processes can be analogy, inductive inference, thought experiment, abduction. Carey introduced Quinian bootstrapping in her explanation of the acquisition of numeral list representation and rational number as well as certain aspects of intuitive physics. Quinian bootstrapping makes possible the creation of new representational systems with novel concepts that were not available in the earlier conceptual machinery. In a word, Quinian bootstrapping underlies radical conceptual change both in the history of science and individual development.

How can we characterise the meaning of mental state terms? Folk functionalism is an intuitive theory in which the meanings of mental terms are organised. According to this common sense functionalist theory, the meaning of a mental term consists of the input and output conditions of the given psychological state as well as the mental state’s connections to other mental states. For instance, the meaning of the term pain consists of the cause of the pain (e.g. touching a hot stove), the pain’s relationship to other mental states (the desire to get rid of the pain) and the pain’s connections to behaviour (pain elicits wincing).

How does the child learn the meaning of mental terms? On the first stage of the ontogenetic acquisition of the semantics of mental terms the child already uses mental terms, but she is not fully aware of their meanings yet. At this stage the child uses mental terms referring to the behavioural components of the mental state only. For instance, the term happiness refers only to behavioural manifestations such as a smile. This phenomenon is called semi-successful reference by Beckwith [56]. This is consistent with Wittgenstein’s view according to which the attribution of mental states is always based on behavioural criteria. The phenomenon of semi-successful reference of mental terms is also in line with Wittgenstein’s well-known remark that we use words whose meanings become clear only later.

Clearly, in this case we can see the learning process of Quinian bootstrapping at work. One of the central components of this bootstrapping process is the existence of a placeholder structure (see above). According to Carey, the meaning of a placeholder structure is provided by relations among external, explicit symbols. In our case, these external, explicit symbols are mental words and expressions represented in the child’s long-term memory. So, the child represents many mental words and lexical items whose full and complete meanings become available only at later stages of this bootstrapping process.

Carey [51] asks one of us what kind of evidence do we have in order to support this first stage in the acquisition of mental terms? Here and now we can provide an anecdotal evidence for this stage. Once one of us observed a two-year-old girl who was clearly playing with her mother’s scarf and during this play she put it around her neck and said: “I have a sore throat.” This observation is consistent with the view that at the beginning the child uses external, behavioural criteria for attributing a mental state to herself. Furthermore, P. Mitchell et al. ([47], p. 329.) writes:” Indeed, children’s earliest use of mentalistic terms usually links with observable behaviour”.

At the second stage of the change of meaning of mental terms the child discovers the inner subjective component (feeling or qualia) of mental lexical items and she realises that the reference of mental terms includes this component. In other words, the child recognises the phenomenological or experiental qualities of mental terms. So within this recognition introspection serves as a kind of modelling process using Carey's terminology of Quinian bootstrapping. In this stage, mental terms have gone through *meaning variance* in relation to the first stage, but the child does not yet possess the full representation of the meaning of mental terms found in the folk functionalist theory (see [52] for more details).

The third stage is the acquisition of this common sense functionalist theory. It is the result of a long learning process during which the child comes to understand the relationship between mental states and their eliciting conditions and the interconnections of mental states to each other and to their behavioural consequences. This is the acquisition of a coherent theory by which the child understands specific causal processes such as the fact that perception leads to the fixation of beliefs, or that beliefs can bring about other beliefs by means of inference and that beliefs and desires cause actions together.

Later in this paper we present an experiment in which we tested the working of this folk functionalist theory in children from 5- to 7 years of age. In that experiment we were interested in how children can explain a protagonist's behaviour by citing mental states. In other words, we asked how children use mental terms in order to explain or predict behaviour.

In sum, mental terms go through changes of meaning during semantic development. The successive naïve psychological theories of children determine the meanings of mental terms. This meaning variance of mental terms is similar to the meaning variance of scientific terms discussed by philosophers of science (e.g., [45]). (In fact, we have borrowed the expression of meaning variance from this philosophical tradition.) As identical terms gain different meanings in different theories, the changes of meaning lead to the problem of incommensurability between various theories. In this way, we can extend the notion of incommensurability to the child's developing theories of mind as well (see [54]).

We have presented the theory of the meaning variance of mental terms in cognitive development. We briefly touched upon the role of introspection in the acquisition of the meaning of mental terms and at the same time we committed ourselves to the so-called theory-theory of mindreading. So the question remains what is the proper role of introspection in the development of theory of mind? As we said above, a crucial aspect of the Quinian bootstrapping of learning the semantics of mental terms is the so-called modelling process by which the mental terms represented in long-term memory get their meanings. And in our view, this modelling process is a kind of introspection. On the one hand, toddlers or young children have mental concepts (e.g., such as a belief); on the other, they have many mental terms in their memory. The cognitive task for the developing child is to find a mapping between the concepts and the mental terms. This mapping is achieved via self-observation. In a word, we do not hold the provocative view of Gopnik [7] according to which first-person self-knowledge is illusory or the less radical approach of Carruthers [44] which claims that the mind is not transparent to itself. As we said before introspection has an important role to play in the acquisition of the meaning of various mental terms.

In our view, the best approach to the development of mindreading is a complex of introspection-based simulation and theory-theory. Our commitment to theory-theory is a kind of semantic determination because we emphasize that both mental concepts and words are embedded in coherent intuitive theories. In addition, the role of introspection as discussed above leads us to accept simulation theory (e.g., [27]).

5 The cognitive developmental investigation of the attribution of privileged access to mental states

Experimental studies of privileged access originate from work by Jürgen Habermas. Within the framework of universal pragmatics developed by Habermas the notion of the ideal speech situation plays a crucial role. In our earlier work [53], we discussed this concept from the point of view of the empirical research on theory of mind in children. Here we would like to address one important aspect of the ideal speech situation, namely that we attribute privileged access to the other person concerning her intentional states. Furthermore, we assume that the other person is able to verbally report these mental states. In other words, we tend to assume that in this ideal situation the other subject has infallible inner eye for her psychological states. This in fact means that we attribute an ability of introspection, therefore first-person authority, to other people. The objects of introspection are intentional states, mental states, certain propositional attitudes (like belief, desire, etc.), psychological states, reasons, intentions, motives, thoughts, emotions, etc.

In this idealisation we do not assume inaccessible, unconscious mental states; instead we assume that the mind of the other is transparent to itself. It is important to see that this is a kind of accountability and eventually responsibility. However, this idealisation exists only in folk psychology because many theorists within psychology deny first-person authority. (See e.g. the whole school of psychoanalysis, [44, 7, 49, 16, 25], and the famous work of Wittgenstein).

What is the relationship between ToM and the attribution of privileged access? From the point of view of empirical research we would like to mention two points. First, within the research on theory of mind development different experiments focus on the questions of how and when children become able to recognise mental states as the reasons or causes of behaviour. These experiments presuppose that once the child comes to recognise that intentional states underlie actions she immediately imputes privileged access to those mental states.

Second, these experiments also presuppose that when the child interprets the other person's behaviour in terms of beliefs and desires, she also presumes that the verbal report of the other concerning the intentional states behind the behaviour would correspond to these mental states; that is to say the child does not take self-deception or confabulation into consideration at the beginning.

Gergely (personal communication) raises the possibility that intentional causation and the above-discussed idealisation are conceptually inseparable. First let us see the option when we take this to be the case. We can only say that this is probably true from a developmental point of view. One of the most important milestones within the research on social representation is the empirical work by Moscovici [55] cited by László [28] that reports the finding according to which Freudian concepts appear in the folk psychology of adults. From this research we know that the notion of the unconscious is present within the everyday reasoning about human action in adults. This implies that adults do not always assume accountability and the ideal speech situation. On the contrary, they tacitly assume that there may exist reasons or other intentional causes which, although play an important role in causing action, are not accessed in a privileged fashion (and hence are not reportable).

From this point of view it is a very important question how the child gives up the ideal speech situation and when she comes to suppose unconscious intentional reasons behind action. We do not know of any empirical data relevant to this issue. Flavell et al. [23] examined the understanding of the unconscious by children. According to their results, this understanding develops in the early elementary school years but this investigation did not address the understanding of the unconscious causes of action in children. It seems that the abandonment of the ideal speech situation is the result of cultural learning.

Of course, according to the second theoretical option intentional causal understanding and idealisation are conceptually separate even in ontogenesis. Let us look at one aspect of this idealisation according to which the child presumes accountability of intentional actions. It is possible that children first understand that mental states cause behaviour and only later do they assume that others can verbally report on intentional states. Maybe the ideal speech situation in this sense requires the active participation in conversations. It is worth noting again that Paul Harris [35] argues that the understanding of belief in three-year-olds is due to the fact that these children already have enough active experiences of conversations. According to him, the two-year-old child forms the mental concept of desire due to her own agency. From the vantage point of the ideal speech situation two-year-old children could understand desire as a mental state but they do not assume that the other person is able to verbally report on it. At this age the child is not able to anticipate imaginary conversations and she could expect the ideal speech situation later only on the basis of internalisation of dialogues and the development of imagination.

In our earlier work [61] we studied the relationship between the attribution of privileged access and perspective taking. In the experiment reported below we used a different method to investigate the attribution of privileged access and by implication the ontogenetic emergence of the ideal speech situation. We place the exploration of the attribution of privileged access into the framework of experimental philosophy. It is worth mentioning that in the novel collection of traditional and experimental philosophical papers [9] naïve theory of mind plays an important role.

Our research questions are the following: When and how do children impute privileged access to others concerning their mental states? What is the relationship between ToM and the attribution of privileged access? In other words, is mindreading a necessary condition of the attribution of privileged access? Or to put it slightly differently, is theory of mind a prerequisite for the ascription of privileged access?

It is worth mentioning that P. Mitchell et al. [47] studied the emergence of privileged access in children and found that even five-year-olds assigned more self-knowledge to themselves than to an adult. This means that 5-year-olds have an understanding of first-person authority. This study, however, did not investigate the attribution of privileged access to others, only to oneself. We explored the attribution of privileged access through minimal narratives. In this experiment, we studied the relationship between mindreading, privileged access and understanding non-literary narratives. Today we witness many attempts to study the different aspects of this relationship. One particular and well worked-out example is the work of Hutto [14]. He argues that the most important part of common-sense psychology is its narrative nature. At the same time, the connection between theory of mind and literary narratives is also an essential research topic within contemporary cognitive science (see e.g. [37]). This relationship is a very important issue in contemporary cognitive narratology. The attribution of mental states (i.e. ToM.) and privileged access to the protagonist is a central feature of all stories. According to Bruner [41], there are two psychological landscapes in every story. The landscape of action consists of the arguments of an action, i.e. its actor, intention, goal, situation, etc. whereas the landscape of consciousness comprises the mental states (e.g. knowledge, belief, feeling, thinking) of the participants. In the experiments reported below, both landscapes played an important role. So far we have seen that understanding narratives has relevance for passing the famous false belief test and the connection between language and mindreading.

6 Experiment

6.1 Methods

Subjects. Seventy five children participated, in the experiment: 25 5-year-olds (mean age: 5:4, range 5:0 to 5:9; 14 boys and 11 girls), 25 6-year-olds (mean age: 6:6, range 6:0 to 6:11; 10 boys and 15 girls), and 25 7-year-olds (mean age: 7:3, range 6:0 to 9:0; 12 boys and 13 girls). The 5-year-olds and the 6-year-olds attended preschools in Pécs, Hungary and the 7-year-olds were first graders also in Pécs in Hungary.

Materials and procedure. We used two stories from the study of Bartsch and Wellman [31] and we added a privileged access question to each of them. The first story is the following: "Here is Jane. Jane is looking for her kitten. The kitten is hiding under the chair. But Jane is looking under the piano. Why do you think Jane is doing that?" This is a backward reasoning task because children have to infer backwards from the protagonist's action to her underlying mental states. (E.g. Jane thinks that the kitten is under the piano.)

Following this, the corresponding privileged access question was: "What do you think, if we asked Jane why she is looking for her kitten under the piano what would she say?" This question relates to the possible verbal report concerning the mental states underlying Jane's action.

The second story is the following: "Sam wants to find his puppy. His puppy might be hiding in the garage or under the porch. But Sam thinks his puppy is under the porch. Where will Sam look for his puppy, in the garage or under the porch?" This is a forward reasoning task because children have to infer forwards from the mental states of the protagonist to his action. (E.g. Sam will look for his puppy under the porch.) So the Jane's story and the Sam's story are different in terms of the direction of reasoning that is required from the child's part.

The privileged access pair of the above question looked like this: "What do you think, if we asked Sam why he is looking for his puppy under the porch/garage what would he say?" Each story was accompanied by a colourful drawing in order to help children to understand the minimal narratives. The order of the two stories was counterbalanced among participants.

Coding. Originally we developed a coding system which consisted of eight categories. The different answer categories were the following: (1) Does not know; (2) Mental states (e.g., "She is looking for her kitten in the kitchen because she *thinks* it is there); (3) Further reasons for action (e.g., "...because she wants *to play with it*"); (4) The physical environment of the drawings (e.g., "...because the garage is bigger"); (5) Goal (e.g., "...because she wants *to find her kitten*); (6) Reality answer (e.g., ...because her kitten *is under the piano*); (7) Perception (e.g., "...because the last time she saw her kitten it was there"); (8) Other.

Later we simplified our category system. As our primary interest is in mindreading and understanding the attribution of privileged access we divided children's behavioural explanation responses into two categories. One of the categories relates to the explanation in terms of mental states (e.g., belief, thoughts etc.) and all the other accounts were grouped into the second category.

Table 4 Percentages of the different answers to the first question in Jane's story.

Answer categories	5-year-olds	6-year-olds	7-year-olds
Does not know	4	20	4
Mental states	52	16	44
Further reasons for action	0	0	4
Physical environment in the drawing	16	20	8
11 Goal	0	4	4
Mentioning location	20	16	12
Perception	0	16	12
Other	8	4	12

6.2 Results

The descriptive statistics of children's answer in terms of the eight original categories is shown in Tables 4-7. As the data in this tables did not lead to significant results we reduced the categories into two as mentioned above.

Regarding our first story (the one with Jane as the main protagonist) 13 5-year-olds (52 percent) mentioned mental states in their behavioural explanation in response to the first question. Interestingly, only four of the 6-year-olds (16 percent) did the same in response to this question. Of the 7-year-olds eleven (44 percent) answered in terms of mental states to this question. In all age groups the remaining children cited other reasons in their response to this question. This result is significant (Chi-Square test: $p<.05$ ($p=0.02$)) presumably because 6-year-olds mentioned mental states in their response less often.

In response to the privileged access question in the first story nine 5-year-olds (36 percent), two six-year-olds (8 percent), and nine seven-year-olds (36 percent) cited mental states. The remaining children did not make reference to psychological states in their answer to the privileged access question. This finding is again significant (Chi-Square test: $p<.05$) for the same reason as mentioned above.

Concerning our second story (the one with Sam as the main character) we made an analysis of the responses to the second privileged access question as a function of the correct/incorrect answer to the first question. Notice that in the story with Sam there exists a correct answer to the first question i.e. Sam will search for his puppy where he thinks it is namely under the porch. The data are presented in Table 8. This table shows that children who answered the first question incorrectly gave much less mental-state-based explanations to the privileged access question than those who answered it correctly (Chi-Square test: $p<.01$ ($p=0.01$).

6.3 Discussion

In response to the first question in the Jane story 6-year-olds mentioned mental states less often than did 5-and 7-year-olds. This is a surprising result which may be due to the fact that 5-year-olds mentioned the "She thinks ... or she believes ..." phrases very often. This is consistent with the general view of Wellman [40] according to whom a kind of explicit belief-desire psychology emerges at the age of 4 and 5. Maybe the emergence of this belief-desire psychology at that age means that this intuitive psychology becomes the dominant explanatory framework and it is only a later developmental achievement that the child considers other kinds of possible accounts as well. But this is only a partial explanation and further research is needed in order to explain this decrease of mental state explanations

Table 5 Percentages of the different answers to the second question in Jane's story.

Answer categories	5-year-olds	6-year-olds	7-year-olds
Does not know	24	32	12
Mental states	36	8	36
Further reasons for action	12	0	0
Physical environment in the drawing	0	20	8
Goal	0	0	0
Mentioning location	24	16	20
Perception	0	20	8
Other	4	4	16

Table 6 Percentages of the correct/incorrect answers to the first question in Sam's story.

	5-year-olds	6-year-olds	7-year-olds
Sam's first question answered correctly	72	68	92
Sam's first question answered incorrectly	28	32	8

in the 6-year-olds. In fact, first we need to repeat this result on another sample to firmly exclude the possibility of a sampling error.

A similar finding emerged in response to the privileged access question in the first Jane story. In response to this question we expected children to verbally report on Jane's mental state but we got relatively few mental state accounts and the general trend was from the children's part to rationalise Jane's behaviour. The decrease of mental state responses in the 6-year-olds can be explained as above.

Regarding our second story with Sam we can say that those children who could predict Sam's behaviour in terms of his mental state correctly gave significantly more mentalistic explanations to the second privileged access question. This finding seems to suggest that there is indeed a close conceptual connection between intuitive theory of mind (as assessed by our first question) and the ascription of privileged access. This is the theoretical option that we discussed in the introduction to our experiment, and further research is needed to separate these two components (i.e. theory of mind and the attribution of privileged access). That is, we have to examine younger children to assess this theoretical option.

In our experiment we tested the working of the folk functionalist theory by which children interpret, explain and predict the behaviour of others using mental state terms. As we saw above, 36 percent of the 5-year-old subjects cited mental states in their responses to the privileged access questions in both stories. We have also seen that according to Mitchell et al. [47] 5-year-olds have first-person authority. This raises the theoretical possibility that children at first have privileged access concerning their own mental states and they attribute privileged access to others only later. But this can mean that as soon as the child discovers that she has privileged access she becomes able generalize this principle to others. This was our original motivation to involve 5-to-7-year old subjects in our study: on the one hand it seems fairly clear that they can attribute privileged access to themselves, and we wanted to see how easily they proceed to understanding others' privileged access. Our results suggest that there may be some delay in this generalization.

Table 7 Percentages of the different answers to the second question in Sam's story.

Answer categories	5-year-olds	6-year-olds	7-year-olds
Does not know	24	32	8
Mental states	36	24	36
Further reasons for action	4	12	12
Physical environment in the drawing	4	4	4
Goal	4	4	0
Mentioning location	16	20	28
Perception	0	4	4
Other	12	0	8

Table 8 Responses to the privileged access question in the Sam story as a function of the answers to the first question: absolute number (per cent)

	Mental-state-based explanations	All other responses
First question correct	23 (31)	35 (47)
First question incorrect	1 (1.33)	16 (21)

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A Hybrid Representational Proposal for Narrative Concepts: A Case Study on Character Roles*

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Abstract

In this paper we propose the adoption of a hybrid approach to the computational representation of narrative concepts, combining prototype-based and ontology-based representations. In particular we focus on the notion of narrative roles. Inspired by the characterization provided by the TvTropes wiki, where narrative devices are discussed across old and new media, we provide a representation of roles based on the integration of a set of typicality-based semantic dimensions (represented by using the Conceptual Spaces framework) with their corresponding classical characterization in terms of necessary and sufficient conditions (represented in terms of Formal Ontologies).

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1 Introduction

In the area of computational models of narrative, and more in general in the field of Knowledge Representation, different approaches to the computational representation of concepts have been proposed. Nowadays, one of the most successfully used formalisms is that one of formal ontologies based on standard Description Logics [2]. Previous work in computational models of narrative has exploited Formal ontologies to model narrative concepts (for a more detailed account see [5] and characters' roles in particular (see Section 2 for a short overview).

One of the main problems for narrative technologies is the need to deal with the representation of the common sense concepts as part of the description of narrative contents. In storytelling, commonsense knowledge includes not only the description of domain knowledge, such as how the incidents characters are involved into in a story, but also the characterization of narrative notions, such as genres, roles, languages, etc. For the representation of such concepts, however, it is not easy to establish a set of necessary and sufficient conditions. In fact, the knowledge about such concepts is usually organized and characterized in prototypical terms and is based on an intuitive, cognitively grounded, characterization. A major problem of the ontology based systems and formalisms, shared with the most of computational models

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of cognition, is, however, given by the fact that they do not allow nor the representation of concepts in prototypical terms nor the possibility of performing forms of approximate and common sense-based conceptual reasoning. In Cognitive Science, on the other hand, evidences exist in favor of prototypical concepts [27].

Since, in our opinion, the representation of concepts in typical terms is crucial in order to grasp the core elements used by humans for reasoning on the narrative knowledge, in this paper we follow the approach presented in [11, 12] and apply it to the case study of narrative roles. We argue that a hybrid solution is suitable for representing and reasoning on narrative roles since it provides an enhanced conceptual model able to better characterize what narrative roles are and how they can be used for concrete reasoning purposes. The solution is hybrid since it combines a typical and a classical representational component (based respectively on conceptual spaces and on ontological framework) each encoding specific reasoning mechanisms. The rest of the paper is structured as follows: in Section 2 a brief overview regarding the narrative roles is provided; Section 3 presents the general conceptual architecture considered for modelling narrative roles; Section 4 describes the Conceptual Space framework employed in our representations; Section 5 shows some simple examples of role modelling according to the hybrid approach and, finally, Section 6 discusses about the advantages of our proposal and about its future extensions and applications.

2 Related Work

The notion of narrative roles dates back to the beginning of 20th century, when the Russian formalist Vladimir Propp proposed a formal account of narrative structures [26]. Propp relied on a corpus of Russian fairy tales to elaborate a model of the structure of fairy tales. Situated at the junction between folkoric studies and semiotics, Propp's account is based on a set of 'character functions', that can be arranged in certain legal sequences according to the rules encoded in a story grammar. Some decades later, Greimas [18] expanded the notion of role into the more general model of actant roles. According to this theory, narratives are defined by a fixed schema of relations among roles, such as the hero opposing to a villain, the helper assisting the hero, the object being pursued by the hero in her/his quest, etc. Thanks to their descriptive potential, structuralist models have been adopted as narrative models in interactive storytelling systems, including [16, 15] and [7]. The system described by [16] employs an ontology, called OntoPropp, to describe plot types in the domain of fairy tales. The system uses the ontology to perform case-based reasoning: given a story plan, searches the ontology for a similar plot, measuring the semantic similarity of the given plot with the plots encoded in the ontology. Inspired by the paradigm of role playing games, the Opiate system [7] creates story plots given user generated story worlds, then casts the available characters into the roles that appear in the plot based on their relevance to the roles. However, Proppian inspired models have been criticized for their inability to face the challenges of interactive applications [3, 15]. Designed for specific genres, they work well for grasping the regularities expressed by the manifestations of those genres, but they are difficulty extended to other genres, failing short to account for the variability expressed by storytelling in new media. In scriptwriting tradition, the systematization of dramatic situation proposed by Polti [25] established the practice of classifying the configurations of characters' oppositions according to fixed schemata, intended to inspire and support the work of authors and practitioners. The 36 situations listed by Polti, each accompanied by a choice of literary works of all kinds that exemplify them, are described with reference to the character roles appearing in them. For example, the situation described as "The

Suppliants" (exemplifies by Aeschylus' tragedy "The Suppliants") encompasses a Persecutor, a Suppliant, a Power in authority, whose decision in favor of the Persecutor or of the Suppliant is doubtful. However, the catalogue of roles that emerges from this classification, despite its claim for generality, is situation specific and open to the authorial creativity. As effectively demonstrated by TvTropes[1], character tropes in today's media can be described along with different dimension, ranging from media specific (such as "Cartoon Character Tropes") to genre specific classifications ("Cops and Detective"). Each character trope is declined into several subtypes each exemplified by a number of individual characters, which possess most of the features of the trope; the same character can be related to more than one trope. While some basic tropes, such as the Villain or the Hero are reasonably similar to structuralist accounts, most of the features mentioned in the typical character trope description do not concern their functional role, but, rather, concern minor, yet relevant features such as appearance, values, etc.

3 Levels of Representations

During the 70's and 80's of the last century, in the context of theoretical debates on connectionism, a classical distinction was in auge between symbolic and sub-symbolic models. While sub-symbolic, or connectionist models, were used for embodying knowledge structures and processes more closely to human-like organizations and processes, many logic-based systems, from which ontological formalisms descend, were developed which were mostly oriented on providing a clear formal semantics, enabling forms of logically-valid automatic reasoning [Brachman and Schmoltze, 1985].

In the AI tradition, the term "ontology" is, referred to "an engineering artifact, constituted by a specific vocabulary used to describe a certain reality, plus a set of explicit assumptions regarding the intended meaning of the vocabulary itself" [19].

The main reasoning tasks performed on such systems are therefore: categorization (the process regarding the class membership assignment to specific instances) and classification (the process through which new subclass relations are inferred). As sketched above, a major problem of such systems consists in the fact that, differently from the connectionist networks whose knowledge structure was organized to deal with prototype-style representations [4], they leave open the problems of representing and reasoning on typicality, which is a crucial aspect of our cognitive abilities. In more recent years, Peter Gärdenfors [14] proposed a famous tripartition of representational levels where, instead of a symbolic/sub-symbolic dichotomy, a further level is considered: namely the conceptual level. This level of representation is intermediate between the other two, and is characterized by a representation in terms of conceptual spaces, i.e. geometrical representations of knowledge that consist of a number of quality dimensions. In such geometrical framework it is possible to represent the concept in prototypical terms and it is possible to perform some forms of simple prototype-based conceptual reasoning without requiring a completely unstructured representation as in the case of classical neural networks (a brief description of the conceptual spaces is provided in section 4).

In this article, by following the approach presented in [11, 12] [2] and firstly applied in [17] we propose to combine, for the computational representation of the "narrative role",

[1] http://www.tvtropes.org

[2] Such approach is also inspired by the so called heterogeneous hypothesis about concepts in Cognitive Science, according to which concepts do not constitute a unitary element and are constituted by different, complementary, bodies of knowledge (for a detailed account on this point see [23]

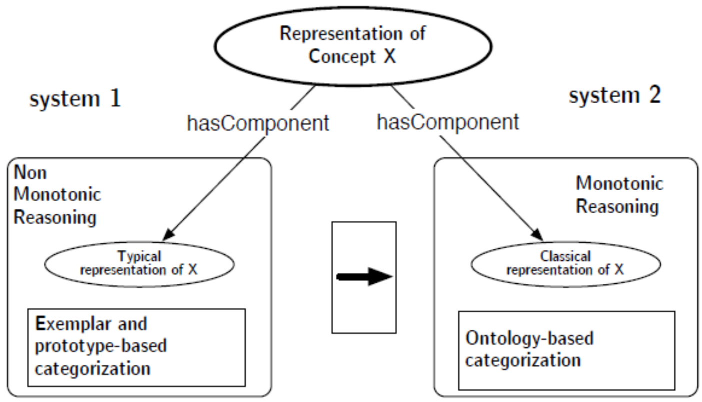

Figure 1 The general architecture for the representation of concepts).

a double level of integrated representations where, for the same concept (e.g. HERO), a characterization in prototypical terms in offered by adopting the Conceptual Spaces framework and the corresponding representation in terms of necessary and sufficient is provided by using the standard ontological formalisms. Such representational distinction also allows dealing with both typical and classical reasoning processes performed on the different bodies of knowledge characterizing the same conceptual entity. The way in which those different reasoning mechanisms, potentially contrasting, are conciliated is based on the dual process theory of reasoning and rationality [6, 20]. This framework postulates the existence of two different types of cognitive systems. The systems of the first type (type 1) are phylogenetically older, unconscious, automatic, associative, parallel and fast. The systems of the second type (type 2) are more recent, conscious, sequential and slow, and featured by explicit rule following. Therefore, given this state of affairs, we propose that the conceptual representation of narrative roles should be then equipped with two major sorts of components, based on:

- type 1 processes, to perform fast and approximate categorization of exemplars (or instances) by taking advantage from prototypical information associated to concepts;
- type 2 processes, involved in complex inference tasks and that do not take into account the representation of prototypical knowledge.

A general picture of the architecture that we want to exploit in this case study is presented in the figure 1. For a detailed description of the cognitive assumptions inspiring this proposal we remind to [21]

4 Conceptual Spaces

As above mentioned, according to Gärdenfors, conceptual spaces (CS) represent an intermediate, geometric–based, level of representation between the sub-symbolic and the symbolic one. It is based on the definition of a number of quality dimensions describing a given concept: examples of this kind are temperature, weight, brightness, pitch for describing the concept of color. To each quality dimension is associated a geometrical (topological or metrical) structure. The central idea behind this approach is that the representation of knowledge can take advantage from the geometrical structure of the conceptual spaces. For example, instances (or exemplars) are represented as points in a space, and their similarity can be calculated in a natural way in the terms of their distance according to some suitable distance measure (e.g. Euclidean Distance or Manhattan Distance). Furthermore, concepts

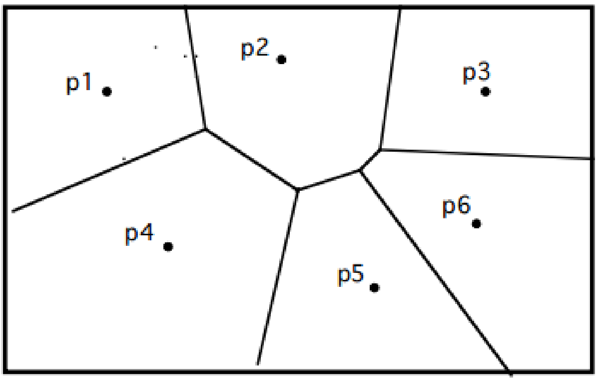

Figure 2 Example of a Voronoi tessellation (from Gärdenfors, 2000).

correspond to regions and regions with different geometrical properties correspond to different kinds of concepts. In particular, concepts correspond exactly to convex regions. In such scenario, therefore, prototypes and typicality effects taking place at the conceptual level have a natural geometrical interpretation: prototypes correspond to the geometrical center of the region itself (the centroid). Thus, given a certain concept, a degree of centrality can be associated to each point that falls within the corresponding region. This degree of centrality can be interpreted as a measure of its typicality. Conversely, given a set of n prototypes represented as points in a CS, a tessellation of the space in n convex regions can be determined in the terms of the so-called Voronoi diagrams (the figure 2 below shows a Voronoi tessellation where p1, p2, pn represent prototypical categorical centers). In sum, one of the main feature of the conceptual space level is represented by the fact that, differently from the models situated at the sub-symbolic and symbolic level, it provides a natural way of interpreting typicality effects on concepts since its geometrical structure allows a direct way of calculating the semantic similarity among concepts and exemplars by using classical metrical distances.

5 Examples: Hero – Anti Hero and Villain in the Hybrid Architecture

In this section we consider some examples showing in which sense the considered hybrid modelling proposal can be beneficial for the representation of narrative roles. We will take into account the concepts of HERO, ANTI-HERO and VILLAIN extracted by the common sense descriptions coming from the TvTropes repository. As above mentioned, in such online repository, typical descriptions of roles are provided that can be useful for practitioners of the narrative field in order to design their own character according to the main assets presented in such schemas. In particular, Tropes can be seen as devices and conventions that a writer can reasonably rely on as being present in the audience members' minds and expectations. Regarding the HERO, TvTropes identifies the following relevant representative features: e.g. the fact that it is characterized by his/her fights against the VILLAIN of a story, the fact that his/her actions are necessarily guided by general goals to be achieved in the interest of the collectivity, the fact that they fight against the VILLAIN in a fair way and so on. Examples of such Trope are: Superman, Flash Gordon etc.. The ANTI-HERO, on the other hand, is described as characterized by the fact of sharing most of its typical traits with the HERO (e.g. the fact that it is the protagonist of a plot fighting against the VILLAIN of the story); however, his/her moves are not guided by a general spirit of sacrifice for the collectivity but, rather, they are usually based on some personal motivations that, incidentally and/or indirectly, coincide with the needs of the collectivity. Furthermore the ANTI-HERO may also act in a not fair way in order to achieve the desired goal. A classical example of such trope is Batman, whose moves are guided by his desire of revenge. Finally the VILLAIN is represented as a classic negative role in a plot and, in line with the actant model by Greimas [18], is characterized as the main opponent of the protagonist/HERO. In addition to this classical contraposition, TvTropes also reports some physical elements characterizing such role from a visual point of view. For example: the characters of this Trope are usually physically endowed with some demoniac cues (e.g. they have the "eyes of fire"). Finally, they are guided by negative moral values. Examples of such role can be easily taken from the classical literature to the modern comics. Some representative exemplars are Cruella de Vil in Disney's filmic saga or Voldemort in Harry Potter.

As a starting point for motivating our proposal let us consider how such roles would be modelled by using standard ontological formalisms and, therefore, by using only necessary and/or sufficient conditions. A possible solution, also taking into account the motivational component of characters structure (in line with the Belief Desire Intention model acknowledged by the literature in computational drama [1, 8, 22] is reported below (classes are in upper cases):

- HERO = PROTAGONIST AND hasOpponent some VILLAIN AND Fight_for only COLLECTIVE_GOALS AND Fight_fairly AND has_Positive_Moral_Values.
- ANTI-HERO = PROTAGONIST AND hasOpponent some VILLAIN AND Fight_for some PERSONAL_GOALS AND Fight_for some COLLECTIVE_GOALS Fight_fairly AND has_Negative_Moral_Values.
- VILLAIN = PROTAGONIST AND hasOpponent some HERO or ANTI-HERO AND has some EVIL_PLANS AND has_Negative_Moral_Values

A first problem of such axiomatic representation is given by the fact that, if we consider the ANTI-HERO roles modelled as a particular type of the general class HERO and also consider that the two classes of COLLECTIVE_GOALS and PERSONAL_GOALS are disjoint, this would lead to a logical inconsistency. Beyond the problem that the ANTI-HERO role would be inherently inconsistent, there is also another problem related to the fact that the typical information about all the Roles is not represented and, therefore, cannot be used to characterize, in terms of similarity/dissimilarity, the differences between the instances. For example: it would not be possible to let emerge the fact that an exemplar of ANTI-HERO, such as Batman, is in between, in terms of semantic distance, between Flash Gordon or Superman and, let us suppose Cruella de Vil. In short, it would be not possible to represent the similarity/dissimilarity among the characters according to a predefined set of conceptual and typical dimensions. In order to deal with these problems we propose, starting from the descriptions in TvTropes, that all the typical elements characterizing narrative roles would be represented in terms of quality dimensions of a conceptual space. The main narrative dimensions that we extracted from TvTropes are the following: Moral Values (represented on a scale of values going from negative to positive), Iconicity (going on a scale from angelic to demoniac iconicity) and Physical Capabilities (identifying, on a numerical scale, how and if a particular character playing a role has special physical capabilities such as, for example, running fast and so on). For each role, a set of famous characters, coming from different narrative genres, was considered for a preliminary modelling experimentation. Namely, we considered Superman for the role of HERO, Batman for that of ANTI-HERO and Cruella de Vil for the Villain. For each character, we assigned it a numerical value for each quality dimension within the conceptual space (namely, *moral values*, *capabilities* and *iconicity*). By doing so, each character is mapped within the obtained space from these three dimensions as a vector of feature values. Notice that a character's position in the geometrical space is a function of the similarity of the vector representing it to the vectors representing the other characters (where the similarity is calculated with the metrics mentioned in Section 4)[3]. In particular, in our case, Superman was represented as characterized by a positive polarization regarding the moral values axis, as exhibiting a stereotypical degree of iconicity (closer to the "angelic" one) and as endowed with strong physical capabilities in virtue of his super powers. On the other hand, Cruella de Vil was characterized by a negative polarization on the moral value axis, by an iconicity based on evil traits and by limited physical capabilities. Finally, Batman was characterized as having controversial moral values (since his action are primarily guided by a revenge desire), by iconicity values closer to the demoniac polarization than to the angelic one and by average physical capabilities (since his "physical power" is exogenous w.r.t the character and is based on the artifacts that he uses). As result of this process, given the described configuration of values for each character, the obtained role space is pictorially represented in the figure 3.

Such typicality-based representational level of roles should be then, in our view, integrated with a lightweight ontological representation based only on the axiomatization of the conflicting dimension characterizing the relations among the different roles to be modeled. The characterization of roles in terms of conflicts with other roles, explicitly stated by Freitag [10] and later embedded in Greimas' actant model, is crucial for the definition of dramatic plots. Thus, the ontological module could be equipped only by the following characterization (reduce w.r.t. the previous one):

- HERO = PROTAGONIST AND hasOpponent some VILLAIN
- ANTI-HERO = PROTAGONIST AND hasOpponent some VILLAIN
- VILLAIN = PROTAGONIST AND hasOpponent some HERO

Such representation, enriched by the taxonomical information that the ANTI-HERO is subclass of HERO, would not lead to any inconsistency. On the other hand, the information regarding the difference about the Goals which are primarily pursued by the agents interpreting the different roles (Collective vs Personal Goals) can be mapped onto the Moral Value dimension within the conceptual space representation, thus avoiding to undermine the overall coherence of the hybrid conceptual representation.

6 Discussions and Future Work

The proposed representational solution for modelling narrative roles presents several advantages w.r.t. a classical ontology-based one. A first advantage, coming from the addition of the prototypical-based representation (formalized in terms of conceptual spaces) is given by the fact that it allows defining the concept of ANTI-HERO in a natural way based on the distance it has with the typical features describing HERO and VILLAIN in the role space. Furthermore, such addition also allows expressing the degree to which a given instance is similar/dissimilar w.r.t. another one based on the topological distance between them within the conceptual space, independently from the class to which it is assigned. As Figure 3

[3] Furthermore, since the results obtained by the metrics can be updated, the character position within the space can change over time based on the individual instances populating the representation.

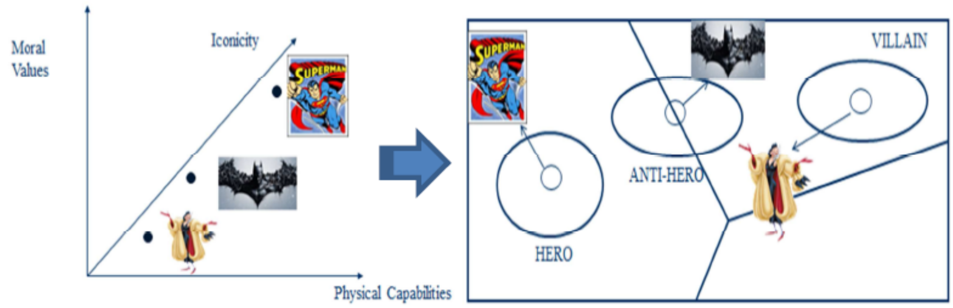

Figure 3 An evocative representation of the conceptual space considering only 3 dimensions (*moral values*, *capabilities* and *iconicity*) and the corresponding Voronoi tessellation.

shows, in fact, it is possible to determine that Batman is more or less equidistant to both the remaining characters represented in this space (Superman and Cruella de Vil[4]).

Furthermore, it is possible to calculate the distance between Superman and Cruella de Vil or, by hypothesizing the availability of a richer conceptual space, the "narrative" distance (according to the considered quality dimensions) between Superman and other exemplars belonging to the category Hero (e.g. Spider Man) or belonging to the other categories (e.g. let us suppose Voldemort or Jean Valjean). Secondly, such representation can be useful in the field of narrative based technologies in order to suggest, to the character designers, which axis (and which regions in conceptual space terms) to consider in order to create novel characters. Different declinations of such characters, and roles, can be taken into account by considering the different points falling within the conceptual regions characterizing, for example, the HERO, Anti-HERO and VILLAIN categories. A further advantage stemming from the proposed solution is given by the possibility of performing a double level of categorization processes based on the different representational levels considered. For example: it is possible to categorize the role of a given character based on both its typical traits (and this process can be performed on the system 1, conceptual space based, component) and on the classical necessary and sufficient conditions charactering its role in terms of conflicts or relations with other roles (this process can be performed on the system 2, ontology based component, by using standard Description Logics reasoners)[5] . Summing up, such representational proposal aims to go beyond the classical ontological role descriptions by taking into account the cognitive and narratological insights which are closer to the audience conceptualization of narrative roles, as exemplified by the knowledge encoded in social web resources such as TvTropes.

A major bottleneck of the proposed approach is given by the selection and characterization, in geometrical terms, of the quality dimensions describing the narrative roles and the exemplars within them. For example, according to TvTropes, a typical trait of the ANTI-HERO is self-doubt, a quality that we did not consider in our current modeling experiment,

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[4] Notice that our example characters were selected for their typicality within their respective roles: as a result, the corresponding Voronoi tessellation results to be very crisp and evenly shaped. In case different, less typical character were selected, their resulting positions in terms of semantic distance would be less evenly distributed within the space. For example, Spiderman (also a Anti-HERO in TvTropes) would be much closer to the classical hero than Batman is, due to its higher altruism.

[5] In case of contrasting results, different conciliation strategies can be used in order to avoid logical inconsistencies. By following the dual process approach, the results coming from the fast, typicality-based module, should be preferred. For a more detailed account on this point we remind the interested reader to [13]

but a relevant one (and almost distinctive feature) for describing Spiderman. Abstract qualities, such as self-doubt, are difficulty mapped onto a some value scale since they do not correspond to uncontroversial perceivable features such as physical appearance. As future work, we plan to leverage automatic techniques for extracting these features from text descriptions for inducing quality dimensions of conceptual spaces from text.

An immediate future work regards the enrichment of the proposed hybrid ecosystem of roles with further dimensions, instances and categories. In addition, this approach seems to be naturally applicable to the concept of Location in a Narrative Environment (for a similar approach to the concept of "narrative echosystems" see [24]). Space and Locations, in fact, can be represented, on one hand, in terms of necessary and sufficient conditions with GIS geo-coordinates (e.g. let us consider for example, the well known Geonames ontology) and, on the other hand, by more typical and evocative features (e.g. Rome can be characterized as the "Eternal City", Paris as "the city of Love" and so on). Since such features allows to cognitively grasp the similarities and oppositions perceived by the audience, they have a crucial importance in the narrative realm.

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Modeling the Function of Narrative in Expertise

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Abstract

The use of narrative is ubiquitous in the development, exercise, and communication of expertise. Expertise and narrative, as complex cognitive capacities, have each been investigated quite deeply, but little attention has been paid to their interdependence. We offer here the position that treating these two domains together can fruitfully inform the modeling of expert cognition and behavior, and present the framework we have been using to develop this approach, the SGOMS macro-cognitive architecture. Finally, we briefly explore the role of narrative in an SGOMS model of cooperative video game playing.

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1 Narratives and expertise

The creation and use of narratives is a crucial component of many forms of expertise, particularly those forms involving multiple actors or which are knowledge-based (e.g., science, medicine, or education). In this context, narratives highlight the most important elements of a situation and package them in a coherent way. This serves four principal functions. First, it allows an individual to form a coherent and tractable representation of a situation in order to act. The most common form of this is the creation of plans according to goals, capacities, and environmental elements. Second, narratives facilitate rapid and precise communication between experts through shared vocabularies (jargon), assumptions, and conceptual frameworks. These shared elements support the establishment of common ground between agents [1] which facilitates the integration of efforts. Third, it allows experts to communicate effectively with the public or non-experts (i.e., those lacking the particular expertise in question) by simplifying complex bodies of information. This communicative function also encompasses the use of narratives in teaching, or translating and transferring expertise. Fourth, narratives are used to position the expert in society and define the relationship between expert and public. Note that the first and second function are closely linked, as are the third and fourth.

To illustrate the first three functions, consider the activities of a medical doctor engaged in treating a patient. In the first stages, the doctor must gather information and integrate this into existing knowledge, develop a hypothesis about what is wrong, and from that

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understanding create a treatment plan (function 1). Following this, the doctor may have to co-ordinate specialist physicians, nurses, pharmacists, and technologists, and this process will be greatly expedited by the group's shared knowledge and vocabulary (function 2). And finally, in order for the physician to communicate important aspects of the problem and proposed treatment to the patient, the doctor will (typically) need to simplify the narrative to make it comprehensible to the patient (function 3). Limitations of space prevent examination of function 4, but see [2] for an excellent treatment of the changing function of the expert narrative within the mental health professions in the 20th century.

In order to understand how expertise is exercised by individuals and coordinated within groups, we must develop a deeper understanding of the intersection of expert knowledge and narratives. To this end, we are working to test two related hypotheses. First, that expertise is structured in consistent ways across both individuals and domains, and second, that these consistencies are reflected in regular patterns of narrative creation and deployment when experts work together. In other words, narratives support a set of functions common to different forms of expertise. This approach is predicated on the idea that the diversity of forms of expertise is largely a function of the different and complex environments in which expertise manifests, while the underlying structure of the expertise is often quite consistent. This is an adaptation of Herbert Simon's "ant on the beach" metaphor [3], in which he argues that the apparent complexity of an ant's behavior as it moves in a convoluted path across a beach is largely attributable to the complexity of the environment, and not to any sophisticated scheming or strategizing by the ant.

2 Integrated cognitive modeling frameworks

In Newell's landmark paper You can't play 20 questions with nature and win [4], he argued for efforts toward theoretical unification. Without these efforts, he claimed, the fields of psychology and cognitive modeling would continue to accumulate experimental data, which could be used to inform theorizing about isolated phenomena and cognitive capacities, but little (if any) progress would be made toward understanding cognitive systems as integrated wholes. Part of the solution Newell proposed was to create cognitive architectures that could be used to model tasks across a variety of domains. An architecture could then be iteratively tested and refined through experimentation in different areas, so that over time it becomes capable of accounting for an ever-broader range of abilities and phenomena.

The framework we have been using is called socio-technical GOMS (SGOMS; [5, 6]), an extension of the GOMS modeling framework [7]. This is an attempt to implement the approach championed by Newell, with a focus on modeling cognition and behavior in complex, multi-agent scenarios. The principal extension is the incorporation of the macro-architecture hypothesis [8], which claims, inter-alia, that there are consistencies in the ways that experts decompose different types of tasks, and that we should use these consistencies in developing systematic methods for the creation of cognitive models. It is a methodological approach aimed at limiting the proliferation of unrelated models and theories. Here, we are primarily concerned with two things: first, how the abilities and limitations of a cognitive system lead to consistencies in the way that tasks are decomposed, both across individuals and across domains, and second, the importance of narrative structures in complex and/or multi-agent task performance.

2.1 Task decomposition: unit tasks and planning units

It is common practice in cognitive modeling to first construct a unit-task model of a task, which is a high-level conceptual model of how an agent divides a task into parts. A single unit-task is a set of operations or actions that can be executed as a unit to achieve some goal. In the GOMS modeling framework, the task is partitioned into unit-tasks such that they help the agent to avoid downtime and overload [8]. With SGOMS, we have added the constraint that unit-tasks should be unlikely to be interrupted, and added an additional, higher-level control structure called planning units, which is typically a set of unit tasks, the sequential execution of which is intended to achieve some higher-level objective. The motivation for these additions is that we wish to model experts in chaotic, multi-agent, real-world scenarios in which interruptions may be frequent and costly, and GOMS models often have difficulty with such scenarios [9]. We believe that experts develop strategies to minimize the impacts of interruptions and to adapt to unexpected events, particularly in situations involving multiple agents and chaotic environments. In such environments, one of the principle functions of a planning unit co-ordination, allowing each individual to react locally without the need to re-convene and create a new global plan. Another function is to allow individuals to efficiently pass information back and forth. And finally, planning units allow for interruption and resumption.

2.2 Cooperative experts and narratives

In recent work [10], we have found that, through cooperative activity, experts quickly develop shared planning units and create names for them. These then become the principal unit of communication by which the experts coordinate their efforts. We consider individual planning units to be "micro-narratives," while the chaining together of multiple planning units forms the overall "expert narrative" that guides each expert's behavior and helps groups of experts to coordinate their efforts. Our conception of narratives owes much to Todorov's idea that narratives consist of passage from one equilibrium to another due to some disturbing force [14]. A planning unit comprises the initial environmental conditions under which its application is appropriate, a final desired state, and a sequence of actions by which the final state may be achieved. This structure fits naturally with production system modeling frameworks, such as the one we are using: Python ACT-R [8]. We turn now to the process of building these models.

2.3 Data collection and modeling procedure

Constructing SGOMS models involves three steps. First, experts in the domain of interest must be observed or recorded performing the activities of interest. By communicating with the expert during this process and taking notes about their behavior, we can sketch an outline of the elements of the task. Second, once this initial sketch has been made, we construct a paper-and-pen process model of the planning units and unit tasks that make up the task. We compare this early model against collected data of expert behavior, which is primarily in the form of video recordings and protocol analysis. We iteratively change and compare the model to incorporate all observed environmental conditions and agent actions. Once we have a model that is capable of accounting for all "reasonable next actions", i.e., experts do not deviate from the action options of the model, we implement the model in Python ACT-R. This third and final step is accomplished via a graphical modeling interface which we have developed. The interface allows a user to create a "virtual paper-and-pen" SGOMS model, while the back-end of the interface can compiles this model Python ACT-R code [10].

2.4 Example model: cooperative video game playing

We have developed a model of two people cooperatively playing a first-person shooter video game, Gears of War 3. This is a very fast, chaotic game, and was chosen because of the high frequency of interruptions and the cooperative mode of play. We do not present the details of the model here, but see [8, 10] for more. The model is presented here to illustrate the usefulness of narrative constructs in modeling expert cooperation.

Our data revealed players using two distinct forms of communication while playing the video game. We have called these “command” and “coordinate”. “Command” exchanges were one or two word utterances, such as “left side”, “he’s charging”, or “run”. This was predominant when there was a lot of action on the screen. In the second form, “coordinate”, the players exchanged longer utterances, such as “set up a cross fire at the opening”. These were strategic adjustments or negotiations, and occurred when there was a lull in the action.

These shifts in communication style were interesting for two reasons. First, the shift from one style to the other was quite marked, and mapped onto clear changes in the action of the game. Second, and more importantly, the utterances made when players were in the “command” style mapped directly onto unit tasks, whereas the utterances made in the “coordinate” style mapped directly onto planning units. Thus we interpreted the cycling between communication styles as players first creating shared planning units (which involved establishing a common narrative for where they were, where they wanted to go, and how to they planned to get there), and then continually updating each other about the current situation. Note that the difference in the function and form of these two communication styles maps quite nicely onto narrative functions one and two, above: “command” represents rapid communication, and ”coordinate” represents plan formation.

A final point of interest is that when we used an “expert-substitution” method, replacing one of the highly skilled players with a novice, we often observed the remaining expert instructing the novice using modified versions of the planning units just mentioned. This effectively “scaffolded” the abilities of the novice, improving the play of the novice quite rapidly. This reflects the third narrative function mentioned above, communication with non-experts.

3 Conclusion

The work presented here has, thus far, been largely exploratory. We have been investigating the intersections and interdependencies of narrative and expertise through cognitive modeling, and have had promising initial results. We have found that the functions of narrative in facilitating the use and transfer of expertise are captured quite nicely by the SGOMS macro-architecture, and are currently developing new models to examine how robust these findings are across domains. Future work will examine both lower-level instantiations of our models (in SGOMS:ACT-R, [10]) as well as higher-level investigations, in models of many-agent models of distributed cognition.

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Plot Analysis for Describing Punch Line Functions in Shinichi Hoshi's Microfiction

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Abstract

This paper proposes a method of describing narrative structure, that focuses on the behavior of the characters in the story. It also proposes to assign the concepts of focus, polarity, dynamic, motivation, and result as attributes of behavior. Utilizing these attributes, the plots of short-short stories by Shinichi Hoshi can be represented formally. Moreover, the method presented here shows that some reversal punch-line patterns can be described using the data captured from plot representations.

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1 Introduction

Through information processing technologies developed in recent years, many quantitative analyses of literature, including bibliometrics, have been carried out in various ways. Though it is difficult to capture all story structures and their interpretations using machines at present, it is possible to incorporate quantitative indicators of narrative analysis in order to enhance the objectivity of the story analysis. Utilizing an eclectic approach including quantitative and traditional humanities methods, such as structural analysis [1] and conventional plot analysis [2], the characteristics of narrative structure and changes in the narrative pattern can be extracted [3]. However, the narrative descriptions produced to date only focus on identifying individual plot functions. Therefore, existing descriptions are not sufficient to extract the narrative functions of the story as a whole, including motivation, behavior, outcome, irony, and other rhetorical devices. Moreover, complex stories with parallel narrative structures have not been analyzed.

The purpose of this paper is to develop a plot analysis method to describe parallel story lines and punch lines. If it were possible to describe punch lines in complex stories, a database suitable for capturing general narrative structure could be realized. Moreover, if a punch line can be automatically extracted from the proposed plot description, it would be possible to compare stories quantitatively and to create "elaborate" story structures automatically using artificial intelligence [4].

2 The goal of plot analysis

Since the purpose is to develop a narrative structure description suitable for a database, the major problem is how to describe the plot as an element of the story. In traditional plot analysis, the plot is generally described as a sequence of functions in each part of the story

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[2]. However, the story functions in a specific portion of text are not always reducible to a single type. Therefore, several story functions, constructed from the words and actions of the characters, need to be extracted in parallel for each portion of the text. In this paper, the plot is defined as the sequence of those parallel functions. In addition, it is necessary to consider the hierarchical structure of story functions in plots. Several functions of a small portion of the text sometimes compose one abstract function in the larger plot structure [5].

Firstly, in order to describe parallel story functions, this paper focuses on the character's behavior. Moreover, the desired outcome of the present study is to arrange and categorize character behaviors and store them in a database system [6]. In order to implement the description of punch lines in the plot structure, it is necessary that all the elements that constitute the punch line are included in the data.

Therefore, as a case study, the plot structure of microfiction known as the "short-short stories" of Shinichi Hoshi, is featured in this paper. Hoshi is the most famous short-short writer in Japan and the author of 1000 short-short stories. The short-short story has many genres, but, as an example of microfiction, is composed of less than 10000 Japanese characters. Most short-short stories have a concise text style and clear punch lines. Hoshi's work is characterized by various plot structures that include a variety of unexpected punch lines.

Although there are many definitions of a punch line, in this paper, a punch line is defined as the unexpected turning point of a story. In many short humorous stories or jokes, these turning points are near the end of the story. Punch lines are positioned near the end in order to arouse readers' feelings at the conclusion. Moreover in other genres, unexpected turning points often take place in the end or the latter part of stories. These turning points also function to arouse interest, excitement, or surprise for readers. In this paper, the definition of a punch line includes all such intentionally-structured turning points.

Based on an analysis of Hoshi's work, the elements required to describe the data regarding various punch lines can be derived. This analysis will be useful for constructing an "elaborate" story.

3 Plot and behavior of characters

When the characters' behaviors are classified and registered in a database, it will be useful to ascribe attributes to them in order to compare their functions in similar stories. For example, if the relationship between the protagonist and antagonist is hostile, the representation of hostility can take various forms, such as the destruction of property, damage of reputation, or physical harm. However, it is desirable that these representations be categorized in a unified manner.

In order to identify the changes in plot structure, it will be useful to identify the active agent, hereafter A, who is the person given agency, and the recipient or intended victim of the action, hereafter B. Furthermore, the motivation of the action and the outcome also need to be distinguished. In addition, the speech acts of A and B need to be included and distinguished from physical behavior so that the role of the punch lines can be captured.

Therefore, in this case study, the behavior of the characters is categorized according to three attributes: focus, polarity, and dynamic. The focus is the type of behavior. The polarity is the negativity or positivity of the effect of the behavior. The dynamic is the relationship between A (the agent) and B (the intended recipient) in the story. The motivation of the behavior and its results are described in accordance with these three attributes in order to record the plot data before and after the behavior.

3.1 Focus, polarities, and behavioral dynamics

Firstly, concerning the focus of behaviors, five major categories (Target, Self, Situation, Intention, and Evaluation) are adopted in this version of the study. Included in those major categories, there are fourteen sub-categories. Secondly, concerning polarity, at least two attributes, negative and positive, are required. In some cases, it will also be necessary to attribute the extent of the polarity involved. In this paper, which focuses on clear reversal patterns of the positive and negative in the punch lines of Hoshi's short-short stories, a bipolar attribute (positive-negative) is employed. Thirdly, concerning the behavioral dynamic, a first-person situation is one in which A's behavior plays the most important role. A second-person situation is one in which the relationship between B and the other characters is assumed. Third-person situations occur when the active agent of the behavior is unclear or unknown.

It is expected that the list of behaviors will vary by genre and author. Hence, it is impossible to prepare a comprehensive list of all behaviors from the outset. Therefore, this paper lists the behaviors necessary for analyses conducted to date. Although the table 1 does not provide a complete list of behaviors in all stories, it is assumed that the list and classifications will be extended appropriately in future analyses.

Table 1 shows the current categorization based on the three above-mentioned attributes, of the characters' behavior that occurs frequently in Hoshi's short-short stories. For example, when the major focus of the behavior is the target and the sub-category is information, positive behavior is related to actions about obtaining information, and negative behavior is related to the concealment of information. In addition, in the case of positive behavior, regarding the behavior (Investigation) that A displays, the most important role is categorized as first person. Behavior (Question) that requires another character to satisfy, is categorized as second person. Behavior (Watch, such as watch TV) for which the source of the information is unclear, is categorized as third person.

3.2 Motivations of behaviors

To make a database of character behavior, in addition to recording the functional attribution of behavior, it seems useful to record the motivations of characters to achieve a deeper analysis of the story. This is because, although the pattern of behavior changes in the story, the underlying motivation can remain the same. However, although Maslow's structure of hierarchical desires [7] is well known, many motivations are not included. For example, he does not include mandatory behavior, habitual behavior, impulsive behavior, anger and frustration, or boredom and curiosity. Therefore, a bottom-up approach to the collection and classification of motivation was adopted. Table 2 shows the current classification of behavior motivation, constructed by listing the motivations necessary for analyses conducted to date.

3.3 Results of behaviors

Information about the narrative progression of stories that results from the characters' behavior is also essential in understanding the structure of the story. Therefore, in addition to the motivation and type of behavior, the results of the behavior should also be classified and stored in a database of plot structures. Table 3 shows the classification of the results of character behavior.

Table 1 Attribute categories of character behaviors in plot analysis.

Focus		Polarity	First person	Second person	Third person
Target (about a concrete object)	Information	*Positive*	Investigation, Discovery, Consideration	Question, Explanation	Observation, Watch
		Negative	Concealment, Forgetfulness	Lie, Pretense	Ignorance
	Material	*Positive*	Creation	Donation, Purchase	Generation
		Negative	Destruction	Theft	Collapse
	Work	*Positive*	Labor	Employment	Service
		Negative	Laziness	Resignation	Unemployment
Self (about the agent itself)	Entity	*Positive*	Birth	Summons	Appearance
		Negative	Death	Killing, Exile	Exit
	Body	*Positive*	Growth	Healing, Dosing	Strengthening, Beautification
		Negative	Decline	Harm	Deterioration
	Perception	*Positive*	Arousal	De-brainwashing	Sanity
		Negative	Dream, Hallucination	Brainwashing	Madness
Situation (about the agent's environ--ment)	Movement	*Positive*	Moving	Transportation	Transportation
		Negative	Stillness	Constraint	Safekeeping
	Relationship	*Positive*	Safety	Friendship, Victory	Peace
		Negative	Risk	Competition	Disturbance
	Circumstance	*Positive*	Satisfaction	Marriage	Prosperity
		Negative	Depression	Exploitation, Divorce	Downfall
Intention (behavior which affects behaviors)	Order, Promise	*Positive*	Compliance	Agreement	Establishment
		Negative	Violation	Default	Obsolescence
	Imperative	*Positive*	Request	Permission	Proposal
		Negative	Restraint	Ban	Criticism
	Assist	*Positive*	Effort	Help	Wish
		Negative	Abandonment	Interference	Curse
Evaluation (about the agent's evaluation)	Assessment	*Positive*	Confidence	Praise	Popularity
		Negative	Regret	Contempt	Unpopularity
	Approval	*Positive*	Boastfulness	Love	Strong point
		Negative	Self-denial	Hatred	Weak point

Table 2 Motivation categories of character behaviors in story plots.

Bodily	Appetite	Improvement, Evaluation	Greed
	Rest, Laziness		Safety, Fear
	Boredom, Delectation		Fame, Beauty
Social	Obligation		Satisfaction
	Custom	Interpersonal	Lust, Love
Knowledge	Curiosity		Antipathy, Anger
	Suspicion		Empathy, Compassion
Subordination	Impulse, Addiction		Guilt, Humility
	Resignation		Contempt
	Inevitability		Respect

Table 3 Result categories of character behaviors in story plots.

Start	The start of behavior, but result is not yet known.
Continuation	The behavior has already started and continues, but the result is not yet available.
Abandon	The behavior is abandoned before the result is known.
Success	The behavior has been completed.
Failure	The behavior could not be completed.

3.4 Nested Behavior Structures

Some behaviors have a complicated object or purpose. Within such behaviors, the object and the purpose of the behavior is a different behavior in some cases. For example, if A is considering purchasing a book, the target of the behavior of his or her consideration is the behavior of purchasing. Furthermore, the object of the purchase is a book.

In order to enable a description of these situations, a nested structure for behavior descriptions is included in the plot data. Here, plots are described as (Agent: Behavior: Target) and "A considers buying a book" is represented as (A: consider: (A: purchase: book)). In the case of two targets of behavior, it is possible to describe these as (Agent: Behavior: Target: Target 2). For example, if A asks B to purchase the book, this can be represented as (A: request: (B: purchase: book): B).

In some cases, there is no depiction of the behavior performed in the story, but only descriptions of commands or requests to perform the behavior are depicted. By adopting a nesting structure of behavior, it is possible to include these types of behavior in the data as well.

4 Describing punch lines

The effectiveness and validity of the proposed behavior classification is examined in the following examples.

4.1 An example of behavior categorization

The first example is taken from Shinichi Hoshi's very short work "Eternal youth," which can be summarized as follows:

> A youth had a date with his girlfriend, but he was visited by a man who introduced himself as a member of the lifestyle guidance committee in the district. The official said that he would give the youth a medicine for perpetual youth and longevity. The youth accepted and took the free medicine.
>
> After the official returned, the youth could not remember the meaning of a date with his girlfriend. Then he read the statement concerning the efficacy of the medicine, which stated that, when someone takes it, they lose all knowledge of and desire for reproduction. Rather than enhance youth and longevity, the medicine was designed to curb the problem of overpopulation.

The sequence of events was divided manually by a coder at the points where the location changes, where the character changes, and where time has elapsed. In this case, the exit of the official divides the story. The reproducibility of the division by two independent coders was evaluated, and was statistically significant [3]. The behavior was also categorized manually. In this case study, the validity of this categorization has not yet been evaluated statistically. In the opening sequence, the youth's behavior is categorized as "Dosing" the elixir of life, and the official's behavior is categorized as the "Donation" of that elixir. In the second sequence, the youth's behavior is categorized as "Forgetfulness" of libido and/or the concept of sexual pleasure.

4.2 An example of plot analysis and a punch line

Table 4 shows an analysis of Shinichi Hoshi's work "Contractant." In the table, at each stage of the development of the plot, the nested behavior of the agent, the target, its result, and the agent's motivation are listed in each row.

Table 4 An example of plot analysis based on categorized behavior.

Plot Stage	Behavior	Result	Motivation
1	(Lucifer: command: work: Devil)	Success	Obligation
	(Devil: abandonment: (Lucifer: command: Devil))	Failure	Laziness
2	(Devil: agreement: (Devil: kill: Man): Man)	Success	Obligation
	(Man1: agreement: (Devil: assist: (Man1: victory)): Devil)	Success	Greed
3	(Man1: request: (Devil: default: (Devil: kill: Man)): Devil)	Failure	Safety
4	(Devil: agreement: (Devil: kill: Man): Man)	Success	Obligation
	(Man2: agreement: (Devil: assist: (Man2: victory)): Devil)	Success	Greed
5	(Man1: proposal: (Man1: competition: Man2): Devil)	Success	Safety
	(Devil: request: (Man1: abandonment: (Man1: competition: Man2)): Man1)	Success	Obligation
	(Man1 and Man2: agreement: (Devil: default: (Devil: kill: Man)): Devil)	Success	Safety
	(Devil: abandonment: (Lucifer: command: Devil))	Success	Resignation
6	(Devil: contempt: “You are the Devil!”: Man1 and Man2)	Success	Anger

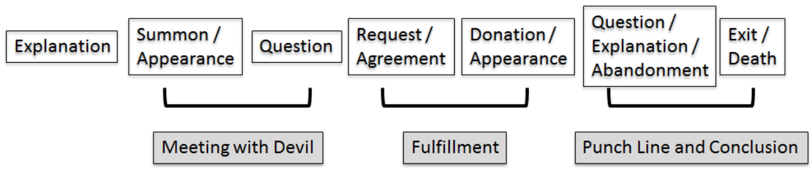

Figure 1 The general pattern of Hoshi Shinichi’s devil stories.

This story can be summarized as follows: according to the command of Lucifer, the Devil makes a contract with a man to take his soul in return for victory in a match. However, the Devil cannot complete the contract because he made the same agreement with two men who compete with each other. Therefore, the Devil relinquishes their souls and blames them for his failure instead.

From Table 4, it can be seen that the relationship of the man and the Devil changes in stage 5 of the plot. Before stage 5, the man asks the Devil to take the life of his opponent, but in stage 5, the Devil requests that he abandon the competition. This is an example of one of the punch-line patterns of reversal between agent A and recipient B. The punch line can be detected as a role reversal that ironically pivots on the same behavior types. The contents of the contract were also reversed in stage 5 of the plot.

4.3 Punch-line patterns in short-short devil stories

As the example in Table 4 shows, it may be possible to identify the position of the punch line in relation to the attributes of the characters’ behavior. Furthermore, Table 5 shows the results of the punch-line classification using the same method, of all sixteen short-short stories about the Devil by Shinichi Hoshi. Table 6 shows the types of reversed punch lines and explains the descriptions of the punch lines.

The punch line types in devil stories, such as agent-recipient, reasoning, trade-off, evaluation, commonsense, and purpose, shown in Table 6, correspond to types of reversal in the stories. Therefore, in many instances, it can be determined that the punch lines relate to reversals of elements of the story. Using the plot analysis of sixteen short-short stories, the basic plot pattern of Hoshi devil stories is shown in Figure 1. Here, the categories of behavior are given above and the explanation of the sequence is below.

Table 5 Punch lines in short-short stories about the Devil.

Title	Reversal Type in Punch Line	Punch Line of Each Story
Mirror	Agent-Recipient	An abuser is killed
Contractant	Agent-Recipient, Commonsense	Humans trick the Devil
Whispers of the Devil	Reasoning	A person's crime is uncovered, because he looks like a good man
Window	Agent-Recipient	A person who blames others is blamed
Devil	Trade-off	A person loses what he gained
Dirty Book	Agent-Recipient, Trade-off	A person is summoned by the Devil A book is bought and sold
Lot of money magic	Evaluation	A person loses what he gained
Trading	Evaluation	Devil loses the ones obtained
Chair of the Devil	Agent-Recipient	A person commands the Devil to die
Conditions	Purpose	Contradiction of desire
Example for the first time	Commonsense, Purpose	A person wants to die Contradiction of desire
Friendly Devil	Evaluation	A person regrets a realized wish
Guy that appeared	Commonsense	The summoned one is not a devil
Trouble and money	Evaluation	A person gives up the desire to take revenge on the Devil

Table 6 Punch line reversal types.

Types	Explanation
agent-recipient	the reversal of agent and recipient
trade-off	the reversal of obtaining and losing
evaluation	the reversal of positive evaluation and negative evaluation
commonsense	the reversal of the general story pattern
reasoning	the reversal of general reasoning / logic
purpose	the reversal of causality such as putting the cart before the horse

Agent-Patient reversal

Plot 1	...	Plot n
A: **steal**: *B*: book		*B*: **steal**: *A*: book

Trade-off reversal

Plot 1	...	Plot n
A: **steal**: book		A: **donation**: book

Figure 2 Examples of reversal patterns.

4.4 Punch lines in plot structure

Furthermore, in other stories that feature a reversal or trade-off in the agent-recipient relation, it is possible to detect the position of the punch line with a computer algorithm applied to the information by extracting the relationship between the recipient and agent of the behavior description.

Specifically, detecting an agent-recipient reversal punch line pattern is possible by searching the database for three conditions, as shown in Figure 2 - firstly, that the same type of behavior exists in another plot; secondly, that the two agents of the same type of behavior differ; and thirdly, the two agents become recipients of the behaviors of others.

In the case of a trade-off reversal, the punch line can be detected by analyzing the reversal of negative or positive behaviors concerning the target object. More specifically, detecting the punch line of the trade-off type is possible by determining that there are several behaviors toward the same kind of target object, the focus of those behaviors is the same in at least two cases, and those behaviors are characterized by polarity.

The commonsense pattern of reversal in the devil stories can be specified by locating the position of the punch line in relation to the general plot description of stories of the same genre. In other words, by comparing with the general plot pattern of the genre and detecting the reversed elements (agent-recipient, trade-off, and so on), the punch line of the reversed commonsense pattern can be detected.

Concerning reversal of purpose and reversal of evaluation punch lines, detection is difficult using the current form of data, but will become possible by extending the behavior description. A reversal of purpose does not appear directly as a component of the behavior, but can be found in the description of the motivation, and it would be possible to analyze a reversal of purpose by adding the contrary relation between motivation and behavior.

For example, “Conditions” is a story in which a person misses the opportunity to become beautiful in the sense that he intends to maintain his handsome appearance. In that story, “beauty” is the motivation because it is sufficient to describe the relation between the behavior of “beautification” and the goal “beauty” in order to extract the reversal pattern in the story. It may also be possible to deal with reversal of the evaluation by extending its description.

Concerning the reversal of reason, it is difficult to detect the punch line by searching for corresponding elements in the narrative plot database. In order to identify a punch line concerning a reversal of reason, it seems that there is a requirement for a new way to describe the causal relation between the behaviors in the plot structure data. However, it is expected that this causal relationship will be very complex and a relational database is not suitable for that process.

5 Conclusion and discussion

This paper proposed a method for describing narrative structures that focuses on the behaviors of the characters in a story. It also assigned the concepts of focus, polarity, dynamic, motivation, and result as attributes of each behavior. Utilizing these descriptions of behavior attributes, the plots of Shinichi Hoshi’s short-short stories can be formally captured. Moreover, it was also shown that some reversal punch-line patterns can be described with the data of the plot representation data.

In some cases, an extension of this method of plot representation is required in order to detect punch lines from the behavior data of the characters. Therefore, in order to describe narrative plot patterns in general and to detect various types of punch lines, the proposed method should be extended by an analysis of other genres.

In order to ensure scientific results, the validity of the categorization for each of the plot functions and attributes should be evaluated. To evaluate objectivity, the kappa value, which represents the correspondence of categorization by two coders, as used in the fields of psychology and cognitive science [8], would be useful.

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A Flexible Framework for the Creation of Narrative-Centered Tools*

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Abstract

To better support the creation of narrative-centered tools, developers need a flexible framework to integrate, catalog, select, and reuse narrative models. Computational models of narrative enable the creation of software tools to aid narrative processing, analysis, and generation. Narrative-centered tools explicitly or implicitly embody one or more models of narrative by their definition. However, narrative model creation is often expensive and difficult with no guaranteed benefit to the end system. This paper describes our preliminary approach towards creating the SONNET narrative framework, a flexible framework to integrate, catalog, select, and reuse narrative models, thereby lowering development costs and improving benefits from each model. The framework includes a lightweight ontology language for the definition of key terms and interrelationships among them. The framework specifies model metadata to allow developers to discover and understand models more readily. We discuss the structure of this framework and ongoing development incorporating narrative models.

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1 Introduction

To better support the creation of narrative-centered tools, developers need a flexible framework to integrate, catalog, select, and reuse narrative models. This paper describes our approach to creating such a framework.

Computational models of narrative enable the creation of software tools to aid narrative processing, analysis, and generation. These narrative-centered tools can help many types of users

1. improve awareness of existing narratives through automated processing of large corpora;
2. increase narrative understanding through detailed and semi-automated analysis; and

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3. increase narrative impact through the development of software tools to assist in narrative authoring and generation.

These tools have great potential to impact society at several levels. Narrative tutors could assist students in learning to read, write, and better express themselves through narrative. Narrative-aware workspaces could assist Hollywood screenwriters, marketers, and game developers to hone their narratives and better target their products. Narrative processing tools could allow news organizations to better track and report on stories across social media.

Narrative-centered tools explicitly or implicitly embody one or more models of narrative by their definition. The model may specify narrative structure (e.g., a beginning, middle, and end), make claims about audience narrative processing (e.g., "this event will confuse many audience members"), or even predict audience responses (e.g., sales of paper towels will raise 23% in this market demographic). Models may be small and simple, such as, "begin your narration in the middle of the action," or models may be large and complex, such as a Bayesian network that predicts audience feelings of Schadenfreude or a model of plot construction using artificial intelligence (AI) planning.

Narrative is a complex phenomenon, and no one model is sufficient for all tasks; what works for radio advertisements in Brazil may not apply to existential French film. Models arise from traditions with vastly different viewpoints [16], such as narratology, sociology, anthropology, psychology, marketing, or educational theory. Furthermore, each singular task may benefit from multiple models; a screenwriting application may use models of plot structure, character emotions, tempo, dialog, special effects, and set blocking, while a comic design tool may use models of visual layout, character backstory, and situational humor.

Currently, despite years of progress in computational narrative (c.f., [13, 5]), most authors still use office productivity tools, such as a word processor. There are few commercially available tools that embody significant narrative models. Part of this is due to the high software engineering overhead of designing, implementing, and leveraging narrative models. Often, these are complex software components that must undergo significant testing to ensure functionality. This cost imparts little proven benefit to justify these high expenses, and no best-practices formal method to codify these theories has been established. The framework presented in this paper begins to address these needs.

2 Related Work

Computational narrative models have been created for over 35 years; for example, the TALESPIN system is often attributed as one of the earliest computational narrative programs [14]. See [13] and [5] for reviews. Two recent workshop series, Computational Models of Narrative and Intelligent Narrative Technologies, have collected much of this work. Prior to the computational work, narrative structuralists began creating formal models of narrative structure, e.g., [17]. However, little effort has been undertaken to date to create open frameworks to incorporate, compare, and use models, especially towards the creation of tools.

There have been several efforts towards the creation of narrative ontologies. Wolff, Mulholland, and Collins [23, 15] created a narrative ontology and surrounding system for the exploration of museum and heritage institution narratives. Tuffield, Millard, and Shadbolt [21] discuss ontological models of narrative fabula, szujhet, and medium, embodied in part in the OntoMedia system [12]. Peinado et al. [18] created an ontology of Propp's model [17], and others have employed ontologies for narrative generation as either specifications of narrative elements or as common-sense databases [3, 11, 4]. Notably, Zarri [24] presents a Narrative Knowledge Representation Language (NKRL). Whereas NKRL presents a full knowledge representation language with associated reasoning to represent the meaning of narratives, the framework presented in this paper does not make definite claims about narrative structure or useful reasoning types; instead, these decisions are left to the individual models of narrative that are part of the framework.

As a particular example of a related system, Finlayson's Story Workbench [6] provides an extensible framework for creating textual narrative annotation tools. This type of system and tool is complementary to the goals of the framework, and is precisely the type of development the framework is intended to support. The annotations provided by the Story Workbench can be directly translated to framework ontology terms, and vice versa, and other systems can more readily make use of these annotations through their incorporation into the framework.

3 The SONNET Narrative Framework

In this section, we describe our progress toward developing a flexible and extendible common ontology and narrative framework that applies to a wide range of potential models of narrative. As defined below, the framework consists of a unified upper-level ontology and an application programming interface (API) against which developers can create models that process narratives annotated with ontology terms. The framework provides a facility to collect, store, and reuse ontology terms and models.

This framework was developed as part of our Studies to Operationalize Neuro-Narratology for Effective Tools (SONNET) effort under the Defense Advanced Research Projects Agency (DARPA) Narrative Networks (N2) program. The goal of N2 is to integrate narrative research from a broad selection of sources. SONNET is a program of research intended to integrate cutting edge research from narratology, computational narrative, and neuroscience to develop tools to assist the layperson in creating impactful narratives. Hence, we refer to it as the SONNET narrative framework, or just 'the framework' for the purposes of this paper.

The framework serves multiple purposes in our research efforts. The framework:

- supports a wide range of tools for narrative processing, analysis, and generation
- supports the development and empirical testing of hypotheses about narrative and audience responses
- enables researchers to identify and codify relationships between narrative research results
- enables researchers to compare and contrast narrative research results in a formal or semi-formal manner
- supports reasoning about the causal chain from narrative element to audience behavior

3.1 Overview

The framework addresses several requirements. First, it considers several types of features:

1. narrative characteristics such as plot patterns or discourse tempo;
2. audience characteristics such as demographics and state of mind;
3. situation characteristics such as to whom, where, when, and how the narrative is delivered; and
4. likely audience responses such as changes in behavior or detectable changes in physiology.

Second, it supports focused applications with models that apply specific domain knowledge. Third, to enable the broadest application possible, it allows for a wide range of model types with few restrictions on model expression.

Figure 1 shows a depiction of a tool-centric computational narrative ecosystem. For example, consider a tool to help parents created educational storybooks for their children. At

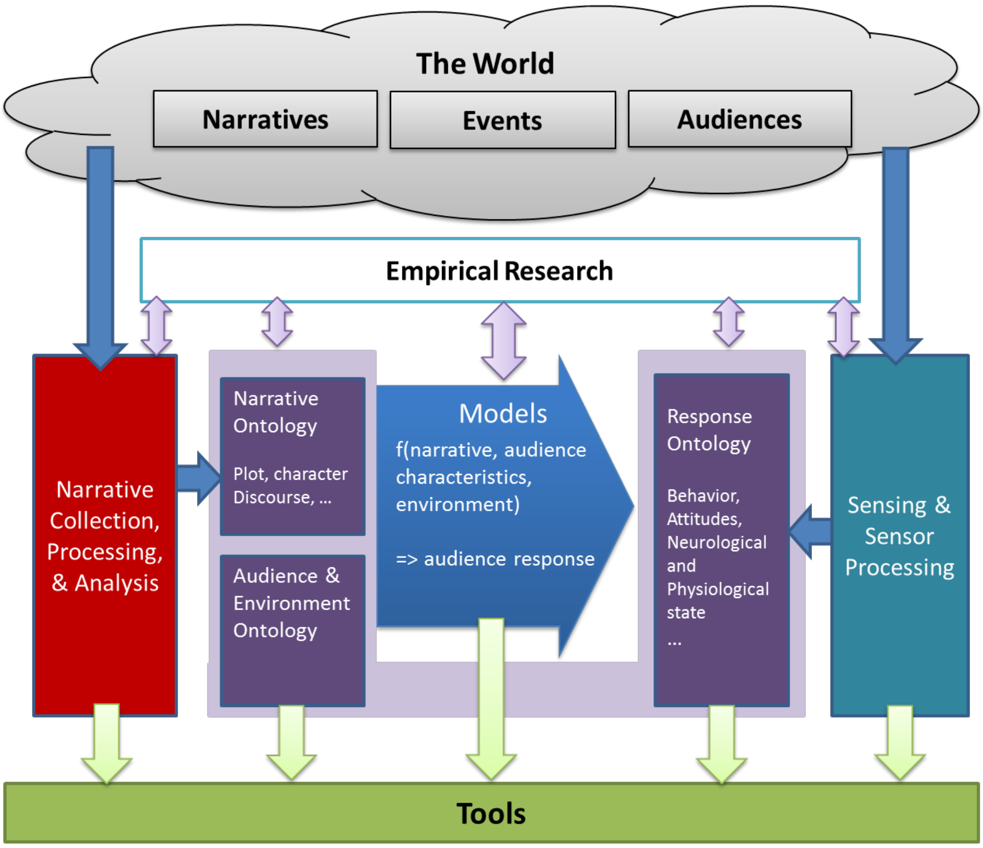

Figure 1 A depiction of a tool-centric computational narrative ecosystem.

the top, narratives, events, and audiences in the real world (such as cultural fables, events in the child's life, and elements such as age group or gender) enter the system through narrative collection; processing and analysis occurs on the left (such as extant databases children's books and fables) and sensing and sensor processing occurs on the right (such focus groups with surveys or even devices such as eye tracking or heart rate monitors). Through these pathways, real-world data is either automatically collected or input manually.

The framework is the central component, consisting of the ontologies (purple boxes) and models (blue arrow). The ontology is an extensible, flexible framework for capturing relevant concepts; that is, it defines the key terms used by the models. In children's books, this may include plot structures, popular characters, morals, and themes. Sections of the ontology that are concerned with specific domains (e.g., sharing or brushing your teeth) are linked by a common upper ontology. The models themselves are mappings between elements of the ontology. A model may map a particular narrative element and audience demographic to an expected audience response. For example, a model may be "two year old children are excited by characters they recognize from other narratives if the character's name is often repeated in the text." However, the models are not solely relegated to the "narrative + audience = response" formula; they may also describe the workings of sensors or narrative processing algorithms. For example, a model may map a change in physiology (increase in heart rate) to a related emotional response (excitement).

In the middle, empirical research may be performed to develop and evaluate any the framework components, such as the effect of name recognition on narrative engagement in

- Type name – name of the type
- Description – a description of the type denoting which entities may be classified as this type
- Super types – types from which this type derives, a type includes all the aspects of its super types
- Attributes – aspects of the type
- Parts – components of the type
- Source – reference material from which the type was derived or the origin of the type definition
- Comments – additional notations

- Type: Bicycle
- Description: Something to ride
- Super type: Vehicle
- Attributes: Color
- Parts: Wheels(2), Chain, Pedals(2), Steering Wheel
- Source: Bob's Book of Bicycles

Figure 2 Left, type definition in the SONNET ontology language, Right, example type of bicycle.

two year olds. At the bottom, the ontology, models, narrative collection, and sensing may be combined into narrative-centered software tools, such as a tool for parents to create new storybooks for their children.

Our primary effort in populating the framework is to

1. conduct research to create these models and
2. support others in the community in incorporating their models.

Model validation and verification rests with the model creator. Instead, this framework provides a vehicle for empirically valid results to be incorporated into narrative-centered software tools.

3.2 Ontology Representation

In creating this framework, we surveyed ontology representations in order to select the one that best met our design goals, including RDFS, KIF, OWL, CL, CycL, KL-ONE, and WordNET [8]. Through this survey, we determined that none of the standardly available ontology representations completely fit the needs of the system, largely because the existing representations introduce complexity not required for the purposes of this framework. Instead, we developed a highly simplified ontology representation and ontology browser.

The ontology represents the definitions of the types of objects in the universe relevant to N2 and our operational communities. The definitions are both concrete entities such as "person" and abstract ideas such as "religion" or "plot structure". We have developed a lightweight ontology language to represent these concepts. Our simple ontology representation was influenced by discussions with Ibuki, Inc. about their proprietary type system. The ontology is a set of type definitions in the format described in Figure 2.

This ontology language is designed to meet the specific needs of the framework. It is lightweight, reducing overhead in ontology creation and maintenance. It is designed for collaboration, allowing others to quickly understand and edit their ontology terms. The ontology does NOT include reasoning. Reasoning is left to the models, preventing overcommitting to a single reasoning algorithm. For example, while rhythm and rhyming may be important to narrative surface text in Dr. Seuss books, reasoning surrounding these elements would be out of place in more prose-centric narratives, such as the Very Hungry Caterpillar. However, the ontology language supports translation to and from existing ontology languages (such as OWL or CL). Because each of these languages incorporates

Table 1 Top level terms in the current upper ontology.

Narrative Type	Audience Type	World Type	Sensor Type
Narrative Narrative Element Narrative World Narrative Theory Setting Character Plot Plot Event Discourse Ordering Attribution Reference Narration Technique Context Perspective Media Time	Person Group Physiology Mental State Individual Differences Behavior Personality Trait Knowledge Value	Geography Type Religion Type Communication Channel Space Framing Software Narrative Analysis Framework Rhetoric	Signal Heart Rate EEG fMRI fNIRS SCR Physiological Processes

multiple useful reasoning and modeling technologies, this approach allows the use of these existing powerful capabilities without overcommitting to a specific algorithm.

Each model is defined through ontology terms and the ontology terms are linked through a common, evolving upper ontology. We anticipate a strong benefit of the framework will be the sharing and combining of models to create products that are more than the sum of their parts. For example, character representation in Clifford books may be examined in the context of character representation in Aesop's fables. This feature enables researchers to identify connections between theories, and it enables lay persons using narrative tools to locate, use, and compose models intelligently.

Table 1 shows the current top level terms in the upper ontology. These are divided into the broad categories of narrative, audience, world, and sensor types. We anticipate the upper ontology will continue to evolve as new models and associated terms are added.

3.3 Model Representation

A model, in this context, is a relationship among terms defined in the ontology, represented in one of many forms. Models may include a simple claim, such as "repeated character descriptions make characters more memorable to young children", an IF-THEN statement, a mathematical formula, a computational function, or even a complex computation model such as a causal influence model, Bayesian net, or system dynamics model. For example, a more complex model may compute predictions for psychological impact based on audience type and plot structure. In our children's books example, this may be a Bayesian net to compute estimated recall of characters based on plot structure, child age, familiarity with characters, and gender.

Metadata is attached to the models to describe why the relationship is believed to be true, and under what conditions. For example, "findings supporting this model were observed in laboratory setting with 100 children, aged 2-4, published paper" or "this model expresses a common feature in the majority of the popular Berenstain Bear novels". This metadata allows both the users and narrative-centered tools to make informed decisions about whether to apply a model and how it may be used in any given context. Models are tagged with this metadata to aid in discovery and understanding by both developers and end users. This metadata includes: overall description, history and creation data (e.g., creator, creation date, and applications), relevant publications and summary of evidence, relevant audiences, key metrics, and a list of the ontology terms used by the model.

At the time of writing, we have integrated multiple models in multiple formats, including:

- Narrative transportation [9, 10, 22]
- Relationship between empathy-induced oxytocin response to narrative, physiological indicators and donation behavior model based on work by the Center for Neuroeconomics at the Claremont Graduate University [2]
- Karma narratives based on N2 research by Richard Gerrig at SUNY Stony Brook
- Narcocorridos, narrative Mexican drug ballads [20]
- Aristotle's Poetics [1]

3.4 Narrative Representation

Narratives are represented in the framework as narrative media with annotations from the ontology. Narrative media may include text, images, audio, and video. The annotations map a portion of the narrative media to an ontology term or terms. For example, the phrase "Once upon a time" in a children's fable may be mapped to the ontology term "Traditional Fairytale Opening", which has a definition describing the meaning and use of this phrase. Similarly, portions of images or segments of audio and video may be mapped to ontology terms. The purpose of the annotations is to enable processing by individual computational models.

As an example of complex narrative processing using the framework, we examine a hypothetical narrative tool to assist children's book authoring using plan-based plot generation (c.f., [19]). Plan-based plot generation uses plan operators, with preconditions and effects, to represent events in the plot, and it applies artificial intelligence (AI) planning algorithms to generate or complete plots to meet specific criteria. To integrate this generation into the framework, ontology terms defining each of the plan operators and the plan data structures are created. A new model is created to represent the planning algorithm, and metadata is added to the model describing the use of the planning algorithm to generate plot structures.

The software application tool integrates with the narrative framework. It prompts the user to select and incorporate plot events, inserting each event as a sentence in the working document that is annotated behind the scenes with associated plan steps, variable bindings, and plan links. The AI planner model is routinely invoked to suggest improvements to the plot for consistency or to meet aesthetic heuristics. The user works alongside the AI planner model to create a final plot.

The advantages of incorporating the SONNET narrative framework for this hypothetic tool are collected when additional models are overlaid on the narrative creation process. The tool may take advantage of models that suggest character descriptions to enhance engagement for young children. It may add additional models to enhance dramatic plot arcs, suggest illustrations, advise character dialog creation, and maintain ideal discourse tempo and length for the young audience. Each model includes its annotations from the ontology. Once these annotations are applied to the working narrative, either automatically or through user input, the respective model can process the narrative and provide its recommendations. Since the tool already has infrastructure to apply annotations and request and receive recommendations from models, development overhead is reduced for each additional model.

4 Conclusions

This paper presents a preliminary approach to creating a flexible framework to integrate, catalog, select, and reuse narrative models. The framework includes a lightweight ontology language for the definition of key terms and interrelationships among them. The framework specifies model metadata to allow developers to discover and understand models more readily, and it represents narratives as annotated media. Lightweight and flexible frameworks such as this one open the door to research community collaboration with low overhead, enabling more rapid advancements and more immediate applications of narrative research results. This framework directly supports tool development by making computational models of narrative more accessible to researchers, tool developers, and potential users alike.

Future and ongoing work includes

1. extension of the model and annotation specification to enable more standardized models where applicable;
2. development of more specific models; and
3. development of narrative-centered tools that use this framework.

A number of open questions remain for the community of researchers, tool developers, and end-users. While the framework currently enables specification of a broad set of possible computational approaches to modeling and processing narrative, which models and ontology concepts may be most useful for end-user applications? How can annotation schemes be defined to be readily applicable to a broad set of tasks? Which annotations can be automated, and which require user input? What application programming interfaces (APIs) can be created to further lessen development overhead. Addressing these questions in future versions of the framework will enable broader adoption, ultimately benefiting the end users of narrative-centered applications.

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Applying Qualitative Research Methods to Narrative Knowledge Engineering*

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Abstract

We propose a methodology for knowledge engineering for narrative intelligence systems, based on techniques used to elicit themes in qualitative methods research. Our methodology uses coding techniques to identify actions in natural language corpora, and uses these actions to create planning operators and procedural knowledge, such as scripts. In an iterative process, coders create a taxonomy of codes relevant to the corpus, and apply those codes to each element of that corpus. These codes can then be combined into operators or other narrative knowledge structures. We also describe the use of this methodology in the context of Dramatis, a narrative intelligence system that required STRIPS operators and scripts in order to calculate human suspense responses to stories.

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1 Introduction

Narrative intelligence includes the ability to generate narratives, explain experiences in narrative terms, and understand and make inferences about narratives. Computational narrative intelligence tasks, such as story generation and story understanding are knowledge-intensive processes. A system would have to know everything that a human would be expected to know about the story domain, and that knowledge could be extensive. For simple domains, such as going to a fast-food restaurant, a narrative intelligence system would need scripts describing the relationship between the customer and the staff, how that interaction changes when using a drive-thru, as well as an understanding of the actions available in such a scenario. As the domain becomes more complicated, the space of required knowledge grows. Compare the fast-food restaurant domain to the knowledge necessary for *James Bond* movies. For the latter domain, it would be necessary to encode the types of problems that

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spies tend to face, the actions that a spy might take to overcome those problems, as well as knowing how to incorporate the gadgets that Bond uses.

Creative narrative intelligence systems, such as story generation and story understanding systems, are knowledge-intensive. Story generation systems typically use a planning approach or a case-based reasoning approach. Planning approaches require knowledge in the form of domain specification (e.g. STRIPS or PDDL), while case-based reasoning approaches require a library of cases. Story understanding systems also frequently use case-based reasoning. When a knowledge-intensive narrative intelligence system demonstrates creativity, it is not clear where credit for that creativity should properly be assigned. Is the creativity, such as the generated story, the result of a good algorithm? Or is it the result of a well-crafted domain? If it is the latter, then the creativity should be ascribed not to the system, but to the designer of the domain.

We propose a methodology for converting a natural language corpus into a domain specification for narrative intelligence systems. Current approaches to converting corpora into domain specifications rely too heavily on the knowledge engineer. By leveraging approaches from qualitative methods research such as ethnography—methods specifically intended to elicit information from texts without being affected by researcher bias—we can construct a domain while limiting the influence of the designer. When domains are constructed using this methodology, it is possible to make stronger claims about the origins of the resulting system's creativity. Because the domain is not the result of too careful crafting by the designers of the system, we can conclude that system creativity is the result of the algorithm rather than knowledge engineering.

In this paper, we present a methodology for extracting narrative knowledge from natural language data and its conversion to a domain usable by a narrative intelligence system. This methodology uses formalized *coding* procedures from qualitative methods research to identify actions and other narrative knowledge in the corpus. Over multiple iterations, coders identify common actions and themes in the corpus. These common themes are used to form a taxonomy of codes which can then be applied by multiple coders to the entire corpus. These codes can then be used to generate narrative knowledge structures, such as scripts and operators. We also describe the application of this methodology to create STRIPS operators and scripts for Dramatis [18], a narrative intelligence system that models human suspense responses to stories.

2 Related Work

2.1 Knowledge Acquisition

A large number of narrative intelligence systems require background knowledge, such as scripts, plans, or other formalisms [5, 26, 15, 9]. In many cases, this knowledge is formed manually. Manual generation leaves the knowledge base prone to the biases of the domain engineers. As a result, artificial intelligence researchers have attempted to automate the acquisition of procedural knowledge (e.g. scripts) from natural language corpora. The Say Anything interactive storytelling system uses sentences collected from a corpus of blog posts [25]. However the resulting stories still needed assistance from human users to ensure that the stories were coherent. Chambers and Jurafsky [2] learn "narrative event chains," which are single-character script-like sequences of events. They analyzed the Gigaword corpus to learn the significant events of a sequence and used machine learning approaches to generate a partial-ordering of these events. Fujiki et al. [8] analyzed Japanese newspaper articles in order to acquire scripts about murder cases. Kasch and Oates [10] collected a corpus of web documents pertaining to a target subject. Once the field of relevant documents has been narrowed, their procedure locates pairs of events based on argument co-reference in order to create script-like knowledge structures. In each of these examples, researchers had access to a sizable corpus of relevant texts, such as newspaper articles about murders.

Depending on the domain in question, the existence of a large useful corpus is not guaranteed. When such corpora are not available, it is possible to use humans to generate specialized corpora. *Human computation* refers to systems that organize people to carry out computational processes, such as tasks that machines cannot typically carry out effectively [13]. A growing form of human computation is *crowdsourcing*. This approach attempts to use "the wisdom of the crowd," where it is believed that the knowledge of a large number of people is superior to that of a single person [13]. In crowdsourcing, the human computation task is distributed to a large pool of people. Frameworks such as Amazon Mechanical Turk (AMT) have been developed as a means of distributing human computation tasks to large numbers of workers, evaluating the quality of the work, and paying them for their brief participation. As human computation and crowdsourcing have grown, researchers have attempted to delegate the acquisition and aggregation of procedural knowledge to large collections of people rather than to automated processes. Boujarwah et al. [1] implemented a process for acquiring scripts from AMT workers. They later used other AMT workers to classify and evaluate the quality of the responses received in the initial script collection phase. Li et al. [14] asked AMT workers to provide the typical events of particular stories, such as dates and bank robberies. In this data collection, workers were given specific instructions about the nature of their responses, such as using simple sentences and only one verb per sentence. Using the crowd-acquired corpora, they automated the learning of script-like structures called plot graphs. However, this approach does not create new stories from the actions in the domain. Instead, it repeats sequences of events that have been provided by the AMT workers. ScenarioGen generated scenarios for serious games using a procedure that combines crowdsourcing with automation [23]. This approach collects scenarios from the crowd, as well as soliciting possible replacements for events in order to create new scenarios. ScenarioGen used satisfiability solvers and K-nearest neighbor techniques to identify when scenarios may require substitute events. Finally, the crowd is utilized again to evaluate the resulting scenarios. While each of these strategies are effective for acquiring narrative knowledge, each comes with a cost. Using AMT workers in three phases—initial collection, classification, and quality control—is a costly proposition when paying workers in multiple domains. While automation reduces the cost of crowd workers, there remains a time cost in ensuring that the learning algorithms are structuring the data appropriately.

2.2 Qualitative Methods

Coding is a qualitative research method used to elicit concepts, theories, or key phrases from natural language data, such as interview transcripts, journals, videos, and other subjective data [20]. It is a common process in fields that heavily utilize qualitative data, such as learning sciences and human-computer interaction. In some cases, coding is one step of a larger approach to qualitative research, such as grounded theory or thematic analysis. A *code* is a word or phrase that summarizes the key details of some aspect of the media being coded. When considering interview data, a code may be applied to a paragraph, or multiple codes may be applied to a single sentence, depending on the particular coding technique being used and the contents of the data. The coding process allows for the identification of similarly themed data when codes are analyzed. Coding is often an iterative process wherein codes are refined as researchers become more familiar with the data and the common themes, or as they attempt to form distinct categories from the data.

Coding is designed for use on the same types of natural language corpora from which artificial intelligence researchers have been attempting to extract procedural knowledge for years. When applied to this context, coding serves as a formalized process for identifying various types of narrative background knowledge, such as actions or event chains, that are implicit within a variety of natural language texts.

3 Methodology

We introduce the following methodology for using coding to convert natural language corpora into knowledge structures for narrative intelligence systems. The description of the methodology is intended to be agnostic as to the source of the corpus as well as the particular representations of the desired knowledge structures. In order to allow for a wide variety of source materials and intended knowledge structures, some decisions in this process are left to the researchers. Some may find it useful to adapt or alter this methodology to better meet the goals of their particular narrative intelligence system. The remainder of this section describes the methodology broadly, while the following section describes the use of this methodology with a particular system.

3.1 Creating a Corpus

This methodology requires a natural language corpus as a source of knowledge for the system under development. The origin of this corpus is not relevant to the procedure and is ultimately dependent on the system in question. Many of the procedures described in related work begin with identifying corpora, each of which would be suitable for this methodology. Surveys, crowdsourced materials, blog posts, game traces, or any other natural language source are applicable to this approach, where the best choice depends on the type of knowledge the researchers wish to encode.

3.2 Coding the Corpus

The corpus is coded in a four-stage process adapted from qualitative methods processes used to parse interview transcripts and ethnographic data, among other tasks. Each individual item (e.g., web page, text sample, or survey response) in the corpus is treated as though it were an interview transcript. For the purposes of this methodology, we will refer to individual sentences or survey answers as *entries*. An *entry* should be the smallest unit of the corpus from which actions will be extracted.

The four stages can be briefly described as follows:

1. Code the corpus by identifying actions, as well as potentially problematic entries within the corpus.
2. Combine actions and problems into broader categories, defining guidelines for what attributes indicate that an entry belongs in a particular category.
3. Multiple coders independently code a subset of the corpus, using the coding guidelines established in the previous phase. Repeat this step until a sufficiently high level of inter-coder agreement is achieved.
4. A single coder from the previous stage codes the remainder of the corpus according to the same guidelines.

The first phase is based on a coding technique known as *Initial Coding* [20, 3]. Initial Coding is a "first cycle" coding method, where researchers produce tentative codes that will later be refined before overall analysis. This process also uses aspects of *In Vivo Coding*

[3, 24], which guides coders to create codes based on the actual words of the corpus. During this phase, a single person codes each entry of the corpus. Entries containing actions should be coded with the verb in the sentence. For example, the entry "The spy orders a drink." should be coded as the action `order`. If there is reason to believe that an entry is not appropriate for conversion to a target knowledge structure, then the entry should be coded with a brief explanation of the problem. Reasons for exclusion depend on the coding task and the system in question and may not apply to all domain engineering tasks. Potential reasons for exclusion could be that the response ignored the survey prompt or presented irrelevant setting details rather than actions (e.g., the entry "It was a beautiful day." could be coded as `setting`).

The second stage uses a process known as *Focused Coding* [3]. This technique is a common "second cycle" coding method that is frequently applied after Initial Coding. The goal of Focused Coding is to identify patterns and categorize the codes created during the first cycle. During this phase, a domain engineer combines the non-action codes from the first stage into a taxonomy of codes that represents the space of possible rejection reasons. Researchers should also create a general code for acceptable entries. Depending on the corpus or the desired knowledge structures, it may be useful to create several codes for entries that represent acceptable actions. For example, it may be useful to have a code indicating that the entry describes multiple actions. The codes created in this phase will be used in later phases. For each code in the new taxonomy, the domain engineer should create guidelines indicating when an entry should be coded as part of this set rather than a different set. The exact number of codes created in this phase, and the breadth of those codes, is ultimately dependent on the corpus and the knowledge domain.

While we describe these first two phases in terms of Initial and Focused Coding, one could also view these phases as a form of *Provisional Coding* [20, 16]. In this technique, researchers establish codes prior to data analysis based on prior experience, related work, and their own expectations and hypotheses. The resulting set of codes can later be modified if observations reveal the need for new codes or a finer level of granularity.

In the third stage of this process, multiple coders (possibly including the original coder from the previous phases) independently code a subset of the corpus using the codes and guidelines created in the previous phase. A sufficiently high level of agreement and inter-rater reliability would indicate that one of the coders could continue to code the remainder of the corpus alone in the final stage with a relatively low risk of error. Using multiple coders in this phase reduces the risk of error, while increasing the confidence in the codes applied to each entry. The corpus subset should represent approximately 20 percent of the full corpus. If multiple prompts were used to develop the corpus, or if there are clear categories of samples within the corpus, each prompt or category should be proportionally represented in the corpus subset. In this phase, when coders apply the code (or one of the codes) for acceptable actions to a particular entry, the code should also specify the action represented in the entry. Taking this step mimics the In Vivo coding technique used in the first phase, as coders should attempt to use the words that were present in the entry. Thus, the entry "The spy orders a drink." would be coded as `Action/order`. Entries that receive rejection codes do not need to incorporate additional information.

After this subset has been coded, calculate the inter-rater reliability amongst the coders. For the purposes of this paper, we use Cohen's κ, though this metric is one of several useful inter-rater reliability metrics and using this one is not essential to the process. Using Cohen's κ, scores greater than 0.6 are typically considered "good" inter-rater reliability, while values greater than 0.8 represent "excellent" agreement [12, 4, 7, 16]. Before starting this phase, researchers should determine what level of inter-rater reliability is sufficient for their knowledge engineering problem and corpus. Statisticians recognize that this threshold is arbitrary, ultimately depending on the task and importance of agreement [11, 20]. Referring to his own *alpha* measure of inter-rater reliability, Krippendorff stated that a threshold of 0.667 could be applicable under certain circumstances [11].

Defining agreement for non-action codes is simple. However, it may be challenging to determine what constitutes agreement in the case of action codes. At a high level, coders may agree that an entry is an action. At a more fine-grained level, agreement may depend on the coders applying similar or identical words to the entry. Using In Vivo coding helps ensure that coders agree on the described action by using the exact words in the corpus.

After any iteration of this phase where inter-rater reliability did not meet the target threshold, the coders should gather and discuss the codes and guidelines. The coders may revise codes or guidelines, or add new codes, in order to improve the level of agreement in the subsequent iteration. Once these revisions are made, the coders should independently return to the corpus subset, coding according to the revised guidelines. These iterations continue until the intended level of inter-rater reliability is achieved. Iterative processes such as this phase are common in qualitative methods such as grounded theory [3].

Once the coders have reached a sufficient level of agreement, a single coder from that group may begin the fourth phase. In this phase, the individual coder applies the most recent revision of the coding guidelines to the remainder of the corpus. Additionally, the coder should resolve any remaining disagreements in codes from the previous phase. This resolution may come from unilateral decision making or through consensus agreement of the several coders. At the end of this phase, each entry in the corpus has a single tag as one of the following:

- An action, and the action that is indicated by the entry. This may be further extended if the coding taxonomy used sub-categories for actions.
- A candidate for rejection, based on the particular code from the taxonomy generated during Focused Coding and revised in the iterative process during the third phase.

3.3 Generating Knowledge Structures

Having fully coded the corpus, it is now possible to convert these codes into the desired knowledge structures. The specific conversion processes depend on the representations used by the narrative intelligence system. For example, converting to Schankian scripts [21] will require a different process than converting to the event chains used by Chambers and Jurafsky [2], or the plot graphs used by Li et al. [14]

In general, each entry in the corpus has now been coded, either as an action or with a reason to exclude the entry. These actions indicate a set of operators in the corpus. Depending on the system or representation, domain engineers may wish to further narrow this set of actions by combining like actions. For example, entries coded as `Action/walk` or `Action/drive` could be combined into the more generic `go` operator, so long as it is not necessary to distinguish between the two original actions in this particular domain. If the engineering task requires some piece of data that was not part of the coding process (e.g., perhaps the process excluded causal information, but the operators being engineered need preconditions), then the domain engineers may have to create this information themselves or infer the information from the original corpus materials.

Given that each entry in the corpus is now coded as an action, the larger items of the corpus (survey responses, web pages, articles, etc.) now contain sequences of actions, which could be converted to narrative structures akin to scripts. As with operator generation, the precise details depend on the nature of the representation. Similarly, domain engineers will need to determine for themselves how to handle rejection codes that appear mid-sequence. Leaving these items out could damage the coherence of a script, but including bad information could be detrimental to the domain.

In any case, the formalisms of the desired knowledge structures will define much of the conversion process. These formalisms should be kept in mind throughout the coding process, particularly during Initial Coding and Focused Coding.

4 Method in Practice

In this section, we describe an implementation of the process described above, as well as some of the decisions that were made as a result of this context. We describe the qualitative knowledge engineering methodology in the context of a narrative intelligence system that uses scripts and plans to calculate the suspense level of stories.

4.1 Dramatis

Our knowledge engineering problem was related to Dramatis, a computational model of suspense based on psychological and narratological understandings of the suspense phenomenon [18]. In order to recognize suspense in the stories it read, Dramatis required a library of actions that could occur in the domains of those stories. These actions are represented as STRIPS operators [6], which are used to plan solutions to possible negative consequences faced by the protagonist. The operator library should include actions that are not present in the story, so that the model could produce alternate solutions to the protagonist's problems. Additionally, Dramatis required script-like structures that indicate typical sequences of events in the story domains. Dramatis uses these scripts to predict possible future events which may affect the level of suspense in the story. In order to evaluate the Dramatis model, we needed to collect these planning operators and scripts.

The planning operators used by Dramatis are typical STRIPS operators, made up of the action name, a set of parameters, and two sets of propositions representing the action's preconditions and effects. With this methodology, our goal was to collect the actions represented by these operators. This acquisition process was not expected to give the parameters, preconditions, or effects for the operators. Parameters would be determined after the fact, based on the context of the actions in the original corpus. The causal propositions were engineered afterwards, so that it would be clear which elements of the domain were necessary to represent and which were irrelevant. However, by collecting operators from an outside corpus, we were able to ensure that a wide variety of relevant operators were included, rather than focusing only on those that occurred to the knowledge engineers.

The scripts used by Dramatis are graphs where nodes represent events and edges represent either a temporal ordering relationship or a causal relationship between those events. Events are represented in the script nodes by the corresponding STRIPS operator. Thus, by collecting actions and converting them to STRIPS operators, we are able to collect the nodes of the script graphs. Because the corpus we used contained sequential event information, we also collected the temporal links for the scripts. The causal links were directly related to the STRIPS operators. Because operator preconditions and effects were authored after the fact, causal links for the script graphs could not be added until the STRIPS operators were complete. Figure 1 shows a fragment of a script for a spy story domain created using this methodology, where solid lines indicate temporal links and dashed lines indicate causal links.

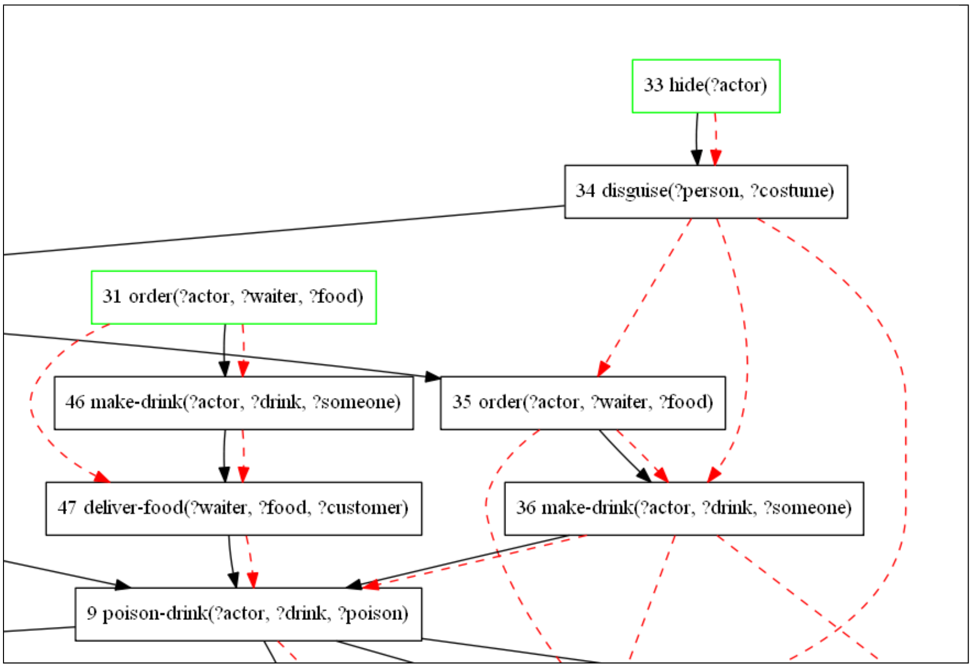

Figure 1 A fragment of a script in the Spy domain.

4.2 Corpus Creation

In order to generate the operators and scripts, we first needed a natural language corpus for the domains which would be used to test Dramatis. These domains were adapted from suspenseful scenes in popular films. The scenes selected were:

- From the film, *Casino Royale*, the scene where James Bond is poisoned at the poker table and attempts to cure himself.
- From Alfred Hitchcock's film, *Rear Window*, the scene where Lisa breaks into Thorwald's apartment to find evidence that Thorwald murdered his wife.

Though we identified these two scenes, it was insufficient to simply use the actions within the scenes as the operators and scripts. While those actions should be included in the operator library, it was necessary for Dramatis to be able to consider the same space of actions that were likely to be considered by human viewers. Using only the actions from the source material would provide the solution, but it would not accurately describe the space of actions available to the characters and the viewers planning on the characters' behalf.

Based on these scenes, we developed three survey prompts based on the crowdsourcing tasks used by Boujarwah et al. and Li et al. [1, 14]. Each prompt described the beginning and end of one of the scenes. Respondents were instructed to list the steps that occurred in the story between these two points. Two prompts were created for the *Casino Royale* example. The *Spy 1* prompt asked participants to describe how a spy could go from being in a bar to being poisoned. The *Spy 2* prompt asked how a spy could go from being poisoned to no longer being poisoned. The *Rear Window* prompt described a scene where two people suspected their neighbor of murder. One of these people was on their way to the neighbor's apartment in search of evidence. Participants were asked to describe the events from entering the neighbor's apartment to being caught intruding by the suspected murderer. Each prompt was written to avoid reference to its source material. The *James Bond* prompts refer to a

Table 1 Knowledge Acquisition Study prompts.

Spy 1	Start: A spy is at a bar or restaurant. Finish: The spy drinks from a drink poisoned by the villain.
Spy 2	Start: A spy is at a bar or restaurant. The spy just drank from a drink that was poisoned by the villain. Finish: The spy is no longer poisoned.
Rear Window	Start: A man (Tom) and a woman (Erin) suspect their neighbor of committing murder. Tom cannot leave the apartment, but Erin has just left the apartment to sneak into their neighbor's apartment to find proof. Tom and Erin have an agreed upon signal for if the neighbor is on his way home. Finish: The neighbor catches Erin in his apartment.

Table 2 Statistics of Knowledge Acquisition Study responses.

Prompt	No. Responses	Total No. of Entries	Median Entries	Mean Entries (SD)
Spy 1	18	131	7	7.28 (3.78)
Spy 2	24	168	5	7.00 (4.79)
Rear Window	18	198	9.5	11.00 (5.11)

generic spy, while character names were changed in the *Rear Window* prompt. Table 1 shows the specific prompts given to participants.

Each prompt was placed in a Google web survey, with 20 numbered blank text fields. The instructions asked participants to describe the events between the prescribed start and end points in the fields provided in order. Additionally, the instructions specified that responses should focus on events or actions rather than setting. Finally, the instructions noted that participants were not required to use all 20 text fields. Prospective respondents were directed to a webpage where all three surveys had been embedded in a random order. Respondents were recruited using institution mailing lists and social media. Table 2 shows the response rates, as well as the average number of text fields used in each response.

4.3 Coding Process

One of the authors of this paper coded the survey responses according to the Initial Coding procedure described in Section 3.2. In the Focused Coding phase, the non-actions codes were reduced to a taxonomy of eleven codes that represented the space of possible reasons for exclusion. Additionally, action codes were divided into two codes: a code for entries representing single actions, and a code for entries representing multiple actions. These thirteen codes were used in the third phase of the coding procedure.

Table 3 shows the thirteen codes and the guidelines used for applying these codes. The reasons for exclusion varied. The most pressing reason was signified by the `Prompt Failure` code, which indicated that the end state of the respondent's story did not match the end state requested by the prompt. Similarly, we coded entries for exclusion when they described the setting rather than actions (`State` code), or provided multiple possibilities for actions without committing to a single action (`Vague` code). We also excluded entries that took an audience point-of-view by referring to discourse-level details, such as events being presented in flashbacks (`Presentation` code). Other exclusion reasons included characters taking

Table 3 Coding Guide for Knowledge Acquisition Responses.

Code Type	Shorthand	Description
Single action	[Specify action]	Applies when the entry describes a single action/operator. Provide the operator in the response.
Multiple actions	[Specify actions]	Applies when the entry describes multiple actions/operators.
Prompt Failure	PROMPT	Applies when the end state of the response does not match the state instructed by the prompt.
Attention	ATTN	Applies when an entry deals with what a character is paying attention to or noticing.
Dialogue Action	DLG	Applies when an entry deals with what a character said. Does not apply when the entry just says two characters talked.
State	STATE	Applies when an entry provides state information but no action.
Thoughts	THGT	Applies when an entry deals with what a character is thinking or thinking about.
Inaction	INACT	Applies when an entry describes a character explicitly not taking an action.
Presentation	PRES	Applies when an entry describes audience point-of-view or sjuzet details.
Incomplete Actions	INC	Applies when a character begins performing an action or task but does not complete it.
Continuation	CONT	Applies when an entry is a continuation of the previous entry, or of the action described in the previous entry.
Continuing Failure	CF	Applies when an entry represents multiple attempts to do something with repeated failure and/or no expectation of immediate success and/or waiting for something to happen.
Vague	VAGUE	Applies when an entry says something happens, but not how; or when an entry provides multiple options for what might have happened.

actions that required modeling their inner state (`Attention` and `Thought` codes) or actions that failed or were repeated over the course of several entries.

The third phase of coding was conducted by the same author as the Initial Coding and a partner. For this phase, we randomly selected five responses from each prompt for the subset, amounting to 23% of the survey responses. During this phase, the two coders agreed on 76.3% of codes (Cohen's $\kappa = 0.64$). Additionally, every time that both coders marked entries as actions, there was semantic agreement about what action was represented by that entry. When codes were reduced to a simple Accept/Reject question (where Accept is a single action or multiple actions, and Reject is any of the eleven non-action codes), the coders agreed on 83.9% of codes ($\kappa = 0.67$). Prior to this phase, we agreed that "good" inter-rater reliability was sufficient. Therefore, only one iteration was necessary during this stage.

In the final phase, the same author coded the remainder of the survey responses according to the same guidelines shown in Table 3. Any coding disagreements from the previous phase were resolved through consensus, though the only remaining disagreements came from entries being coded as actions by one person and given non-action codes by the other coder. At

Table 4 Sample Survey Response with Initial and Final Codes.

Response	Initial Code	Final Code
A man (Tom) and a woman (Erin) suspect their neighbor of committing murder. Tom cannot leave the apartment, but Erin has just left the apartment to sneak into their neighbor's apartment to find proof. Tom and Erin have an agreed upon signal for if the neighbor is on his way home.	Restatement of prompt	STATE - State information
Erin discovers a red herring.	Action - discover	Single action - discover
Erin becomes afraid of a noise.	Emotion	THGT - Thoughts
Erin realizes the noise was something innocent.	Realization	TGHT - Thoughts
Erin finds a clue.	Action - find	Single action - find
Erin goes where she cannot see Tom's signal.	Action - go	Single action - go
Erin finds gruesome evidence.	Action - find	Single action - go
Erin hears the neighbor arrive home.	Passive, hearing things	ATTN - Attention
Erin hides.	Action - hide	Single action - hide
Erin continues to hide as the neighbor moves.	Continuing action, action - move	CONT - Continuation
The neighbor catches Erin in his apartment.	Restatement of prompt	Single action - catch

the end of the process, each entry from each survey response had been tagged as one of the following:

- A single action, and what action is indicated.
- Multiple actions, and what actions are indicated.
- A candidate for rejection, along with the specific rejection code from Table 3.

Table 4 shows one complete response to the Rear Window prompt. The middle column shows the results of the Initial Coding process, while the last column shows the codes after all phases of coding had been completed. This particular entry was coded by both coders. The only disagreement between the coders came on the third entry. One coder listed the entry with the rejection code for character thoughts, while the other coded the entry as a single action `become-afraid`. During the final phase, this disagreement was resolved through consensus, and the rejection code was ultimately selected.

4.4 Generating STRIPS Operators

Prior to converting the coded survey responses to the knowledge representations used by Dramatis, we removed any response with an entry coded as `Prompt Failure`. This code indicated that the respondent did not adhere to the prompt, typically by failing to meet the specified conditions at either the beginning or the end of the story. As a result, the entire response was not useful. Other rejection codes only affected the single entry rather than an entire survey response.

After the coding process was completed, each identified action was converted into a STRIPS operator [6]. Similar actions (e.g. "sneak" is a special case of "go") were combined into single operators. The coding process provided the action, or the verb, for the operator. However, STRIPS operators require parameters, preconditions, and effects, none of which

```
operator:  deliver-food (?waiter ?food ?customer)
    constraints:  person(?waiter) person(?customer) edible(?food) (neq
        ?waiter ?customer)
    preconditions:  has(?waiter ?food) ordered(?customer ?food)
        waiter(?waiter)
    adds:  has(?customer ?food)
    deletes:  has(?waiter ?food) ordered(?customer ?food)
```

Figure 2 Example Planning Operator.

were immediately derivable from the survey responses during the coding process. In some cases, parameters could be inferred from the original text entry, such as parameters which pertained to the subject or direct object of an action. STRIPS operators often require additional parameters that describe details that are implied by natural language. For example, the `give` operator would require a location parameter to make sure that both characters involved are co-located. However, the single sentence describing the act of giving usually would not contain location information. Operator preconditions and effects were inferred from how the actions were used in the survey responses, rather than from the coding process. Preconditions and effects were also modified later as the operators were tested and interactions between them were observed.

Figure 2 shows an operator created from the Spy prompts. The `operator` row shows the operator name and parameters. The `constraints` and `preconditions` lines show operator constraints and preconditions, where constraints are a special subset of preconditions that establish immutable facts about the parameters in question, such as a parameter variable referring to a person. The `adds` and `deletes` lines refer to propositions that are added and deleted, respectively, from the world state as effects of the operator being completed. The full set of operators created for both the Spy and Rear Window domains can be seen in [17].

4.5 Generating Scripts

After the operators were finalized, we combined the survey responses into a script for each prompt. Each survey response represented a portion of the script, making up a path through the script graph. When entries were coded as actions, the corresponding operator was added to the scripts. Entries coded as non-actions were skipped, unless doing so affected the coherence of the story in the survey response. Typically, an existing operator was relevant to the entry despite the code. Additionally, in some cases, events were included in the script trace that had been left implicit in the original survey response (e.g., the operator `make-drink` was specified between `order` and `deliver-drink` by some participants, but not all). Figure 1 shows a portion of the script created from the Spy 1 prompt. The complete scripts for the Spy and Rear Window domains can be seen in [17].

Additional information was added to the script representation once the sequences of actions had been collected from the coded survey responses. Dramatis scripts required causality information about the events of the script. These causal links were added based on the preconditions and effects that were created for the operators. We also annotated the script so that it was clear when the same character was expected to perform several actions. These annotations were derived from the survey responses directly.

4.6 Discussion

The resulting operators and scripts were successfully used to evaluate the Dramatis model [18]. The knowledge acquisition and coding procedures led to 62 operators for the *Casino Royale* scene based on the two spy domain prompts, and 38 operators for the *Rear Window* domain. The *Casino Royale* and *Rear Window* scripts had 51 event nodes and 44 event nodes, respectively. Dramatis used these operators and scripts to find possible solutions for characters facing negative consequences, which was part of the process of calculating suspense responses. In system evaluations, we demonstrated that Dramatis produced suspense ratings that corresponded to ratings produced by human readers, in part because of how the model used this narrative knowledge [18].

It is possible that a second iteration of the third phase, using multiple coders to code a subset of the survey responses, could be beneficial to the knowledge structures used for Dramatis. While we were satisfied with the "good" Cohen's κ of 0.64, we were still distant from "excellent" agreement ($\kappa \geq 0.8$). Further iterations would provide greater confidence in the individual coding completed in the fourth phase of the process. However, it is notable that this inter-rater reliability calculation does not take into account the semantic agreement on the actions between the two coders. Rather, it only notes when both coders marked an entry as `Single action` or `Multiple actions`. Accounting for the agreement in action descriptions might increase the inter-rater reliability calculation.

It is important to recognize that the codes used for Dramatis (Table 3), while appropriate for our prompts, are not necessarily applicable to all knowledge engineering tasks. Other researchers will need to go through the same initial processes, using Focused Coding to develop their own taxonomy of codes, allowing the codes to emerge from the corpus. It is not difficult to imagine other systems that have other criteria or would want to include entries that we excluded. For example, where we excluded dialogue actions, others may want to encode such entries in their knowledge base. These decisions must be made prior to Initial Coding and depend entirely on the goals of the researchers.

5 Future Work

While we were able to successfully generate operators and procedural knowledge using this methodology, we needed to author causal knowledge by hand after the fact. Future work should focus on how to extract causal information from natural language corpora using qualitative methods. It may be possible to build on the work of Sil and Yates [22] in order to collect some of this causal information automatically. Further effort is also necessary to determine the best way to collect causal information from the crowd. While crowdsourcing has proven effective for providing sequences of events, it is not yet clear whether it is reasonable to expect untrained AMT workers or survey respondents to provide the level of causal information needed to produce STRIPS operators or other structures including causality. A number of narrative systems also consider the intentionality of its characters [19], which this methodology has not addressed. Further research will help determine how corpora can be coded in order to extract the goals and intentions of the actors described in the texts. Finally, it may be valuable to extend this process beyond natural language texts to media such as films and games. Including these other media will likely require alterations to the methodology. However, the gains for narrative researchers will be significant if they are not limited to text-only formats when using this approach.

It may be useful to evaluate this methodology by comparing it to one of the other knowledge acquisition and engineering processes discussed previously. For example, if we could evaluate the quality of the knowledge structures generated using this approach, we could compare the resulting structures to those created using the automated processes described by Li et al. [14] or other hand-tailored approaches to knowledge engineering. Evaluating the quality of a knowledge structure remains an open questions, but could perhaps be accomplished by considering how well the narrative intelligence system performs with that particular set of knowledge.

6 Conclusions

We have introduced a methodology for creating a narrative intelligence domain from natural language corpora using techniques from qualitative methods research. This technique mitigates the influence of system designers in crafting the knowledge needed by the system in question. Additionally, we demonstrated the use of this methodology in the context of Dramatis, a system that demonstrates narrative intelligence by calculating a reader's suspense response. Our methodology was used to generate STRIPS operators and scripts which Dramatis used as part of it calculations.

By limiting the role of the designer in the knowledge engineering process, designers can make stronger claims about the creativity of their systems. Using this methodology, we can assign credit for creative results to the algorithms used by narrative intelligence systems, rather than to the domain designer. Knowledge-intensive systems, such as story generators and story understanding systems, will always need knowledge that is comparable to what humans would be expected to know in the same domains. Codifying the process for converting from corpora to domain, while simultaneously mitigating the influence of the designer, will allow researchers to have greater confidence in the source of the creativity of their systems.

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Gathering Background Knowledge for Story Understanding through Crowdsourcing

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Abstract

Successfully comprehending stories involves integration of the story information with the reader's own background knowledge. A prerequisite, then, of building automated story understanding systems is the availability of such background knowledge. We take the approach that knowledge appropriate for story understanding can be gathered by sourcing the task to the crowd. Our methodology centers on breaking this task into a sequence of more specific tasks, so that human participants not only identify relevant knowledge, but also convert it into a machine-readable form, generalize it, and evaluate its appropriateness. These individual tasks are presented to human participants as missions in an online game, offering them, in this manner, an incentive for their participation. We report on an initial deployment of the game, and discuss our ongoing work for integrating the knowledge gathering task into a full-fledged story understanding engine.

1998 ACM Subject Classification I.2.4 Knowledge Representation Formalisms and Methods

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1 Introduction

A defining characteristic of human intelligence is our ability to comprehend stories based on previous experiences and acquired knowledge. These experiences and beliefs act as background knowledge for the comprehension task. To create a system able to understand stories, we must first devise a method for gathering such background knowledge from some appropriate source in a form that can be later used by a story understanding engine.

This paper describes our ongoing work for this knowledge acquisition task. It focuses on describing a method for acquiring background knowledge through crowdsourcing, and it initiates an investigation of whether a *fully* crowdsourced method for knowledge acquisition is feasible, and competitive against other automated or semi-automated approaches.

The paper is organized as follows: First, the formal framework used to represent and reason with the background knowledge is analyzed, and our approach is compared to other existing works. The methodology used to gather background knowledge is then presented, as a sequence of steps needed to get from raw text to structured knowledge. We cast our methodology as a crowdsourcing task, and demonstrate how Games With A Purpose (GWAPs) can be used to implement it. Finally, an empirical setting and results from an initial deployment of our developed GWAP are presented. We conclude with future work.

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2 Related Work and Background

One can think of a story understanding engine as comprising three main modules:

- a module for converting stories from a given modality (e.g., text) to a formal representation
- a module for gathering background knowledge and representing it formally
- a module for reasoning by integrating story information with background knowledge

We discuss related work in terms of these three modules. Since the early seventies, a plethora of systems and models have been developed for story understanding. Charniak [4] proposed a story comprehension model for answering questions about children stories by relating stories to real-world background knowledge. The same author also proposed the Ms. Malaprop [5] system, which answers questions about simple stories dealing with painting. That system uses stories entered in a semantic representation format and answers questions using rules of the same format. Hirschman et al. [13] described the work done on Deep Read, an automated reading comprehension system that accepts stories and answers questions about them. Mueller [26] proposed a system for modelling space and time in narratives about restaurants, which involved the development of an information extraction tool to convert narrative texts into templates about the dining episodes discussed in the narratives. These templates were used for constructing commonsense reasoning problems.

Most of these systems are focused on a specific domain or subject area, like terrorism, painting, dinning in restaurants, etc., and require specific background knowledge based on the respective topic. The story comprehension level of the majority of these systems is also limited to the basic events covered in each story and the key actors involved.

In an analogous context, Gordon and Schubert [11] proposed a method for acquiring conditional knowledge by exploiting presuppositional discourse patterns to create general rules. Clark and Harrison [6] developed a system able to extract simple statements of world knowledge from text, which aims to improve parsing and the plausibility assessment of paraphrase rules used in textual entailment.

The importance of background knowledge in story comprehension is also backed up by reports coming from Psychology; see, for example, the work by Diakidoy et al. [7, 8] and references therein. Certain researchers in the field claim that the appropriate knowledge for this type of systems is based on general axiomatic formulations of different facets of the commonsense world [12]; others claim that symbolic representations [29] or concrete rules [14] are the right way to represent background knowledge, and yet others claim that routine behavioral activity that operates using purely procedural representations is the appropriate format [1]. A hybrid approach is proposed in [27] and [31], where background knowledge is allowed to be represented in a variety of formats. This diversity makes it more likely to gather appropriate background knowledge for whatever commonsense problem one is faced with at the moment. We adopt the approach that background knowledge is represented in terms of rules (cf. Section 2.1), which correspond to loose associations between concepts, in line with relevant psychological evidence [17, 21].

According to Mueller [25], a story understanding engine should be able to acquire broad and deep background knowledge. There are many initiatives for collecting and distributing background knowledge, including Open Mind [31], ConceptNet [20], WordNet [9], PropBank [16], FrameNet [2], etc. Most of these initiatives acquire knowledge by posing questions to volunteers on specific subjects, and represent knowledge in an unstructured (textual) or semi-structured (network of keywords and relations) form.

During the last several years, we have witnessed the blossom of crowdsourcing techniques and more specifically Games With A Purpose. Crowdsourcing is a relatively new term and is typically defined as 'a strategy that combines the effort of the public to solve a problem or produce a resource.' [36]. GWAP [34] is a genre of crowdsourcing and is best described by existing applications such as the ESP game [35] and Verbosity [33]. We adopt, in this work, the use of GWAPs as the mechanism for acquiring commonsense knowledge.

There are certain other attempts that use GWAPs to acquire commonsense knowledge, such as the Common Consensus game [19], which aims to collect commonsense knowledge from people's everyday goals, and the Restaurant Game [28], where player actions and behavior in a virtual restaurant world are recorded, encoded, and visualized on a plan network. Boyang et al. [18] proposed a system for creating narratives through crowdsourcing by using the representation of plot graphs.

2.1 Knowledge Representation and Reasoning

We are interested in obtaining background knowledge that can be used in the context of multiple stories. We take the approach of representing knowledge in a structured form, using a high-level version [22] of the Event Calculus [30], with the aim of exploiting formal reasoning systems (e.g., [7, 8]). In the sequel we use the following terminology and notation:

A fluent F is an object whose value can change through the course of time like quantities or propositions [30]. An action A is an event that occurs at a specific time-point. A literal L can be a fluent or an action, or their negation. The following types of rules are used:

- ϕ `implies` L: Denotes a formula ϕ over actions and fluents that implies literal L. Rules of this type correspond to constraints that hold at each story time-point. The rule person(X) `implies` can(X,think), for example, intuitively means that every person X can think.
- ϕ `causes` L: Denotes a formula ϕ over actions and fluents that causes literal L. Rules of this type capture the conditions ϕ whose presence at some time-point is sufficient to change the state of L at the next time-point. The rule attack(X,Y) `causes` war(X,Y), for example, intuitively means that when X attacks Y it causes a war between them.

A story is taken to be a sequence of literals that hold or occur at certain time-points [23].

3 Gathering Background Knowledge

Following our main goal of investigating whether a fully crowdsourced approach suffices for knowledge acquisition, we propose a general scheme for going from raw text to background knowledge represented in terms of structured rules. We illustrate the steps of our methodology below, using the following simple story snippet as a running example:

Story snippet: A cat chased the mice. The mice managed to hide in a nearby hole.

Step 1. A story is selected and is split into sentences, using punctuation marks to determine the end of each sentence. A sentence is then selected for processing. Human participants are asked to remove articles (e.g., 'a', 'the'), change the tense of verbs (e.g., 'chased' to 'chase') and lemmatize words (e.g., 'mice' to 'mouse'). This step converts sentences and words to a simpler form by reducing inflectional forms, and removing stop words.

Selected sentence: A cat chased the mice.
After processing: cat chase mouse

Step 2. Human participants are asked to identify nouns and verbs given the previously processed phrases. The outcome will be later used to produce formal expressions, which allow verbs being used as predicate name and nouns being used as predicate arguments.

Selected phrase: cat chase mouse
After separation: {cat, mouse} are nouns, and {chase} is a verb

Step 3. Predicates are constructed using verbs and nouns from the previous step. More specifically, human participants choose which verbs to use as predicate names and which nouns to use as predicate arguments. In addition to nouns, each constructed predicate can be used as an argument for new predicates that are created, leading to higher-order predicates. Human participants are required to choose whether a predicate is an action or a fluent.

Selected words: {cat, mouse} are nouns, and {chase} is a verb
Formal expression: chase(cat,mouse) is an action

Step 4. The next step seeks to identify logical rules that are built on the identified predicates. What is expected here is for the human participants to introduce new predicates that are not explicitly present in a sentence, but are implied by it, and relate those new predicates to the existing ones in the form of rules. For each rule, human participants are asked to specify whether this rule causes or implies the deduced predicate.

Selected predicate: chase(cat,mouse)
Possible rule 1: chase(cat,mouse) `causes` fear(mouse,cat)
Possible rule 2: chase(cat,mouse) `implies` can(cat,run)

Step 5. In the penultimate step, human participants generalize previously identified rules. For each rule certain predicates and arguments can be chosen and replaced with variables. When an argument α is replaced with a variable V, a new predicate of the form $\alpha(V)$ is appended to the body of the rule. Human participants can choose whether this predicate should be retained. Effectively, this step transforms each rule to a form that is applicable more generally and not only in the context of the story or sentence from which it originated.

Selected rule: chase(cat,mouse) `implies` can(cat,run)
Possible generalized rule 1: cat(X) `and` chase(X,mouse) `implies` can(X,run)
Possible generalized rule 2: chase(X,Y) `implies` can(X,run)

Step 6. During the final step the acquired knowledge is validated. First, a sentence other than the one from which a given rule originated, is selected. Human participants are asked to verify whether the conditions in the body of the rule are met in the context of the selected sentence. If they are, human participants are asked to decide whether the head of the rule follows from the sentence. If the player answers affirmatively to the first question then the rule receives a positive applicability vote; otherwise, the rule receives a negative applicability vote. If the player answers affirmatively to the second question then the rule receives a positive validation vote; otherwise, the rule receives a negative validation vote.

Selected context: A policeman was chasing a burglar near the town center.
Selected rule: chase(X,Y) `implies` can(X,run)
Results: The conditions in the body of the rule are met in the context of the selected sentence, and the head of the rule follows from the selected sentence. Thus, the rule receives a positive applicability vote and a positive validation vote.

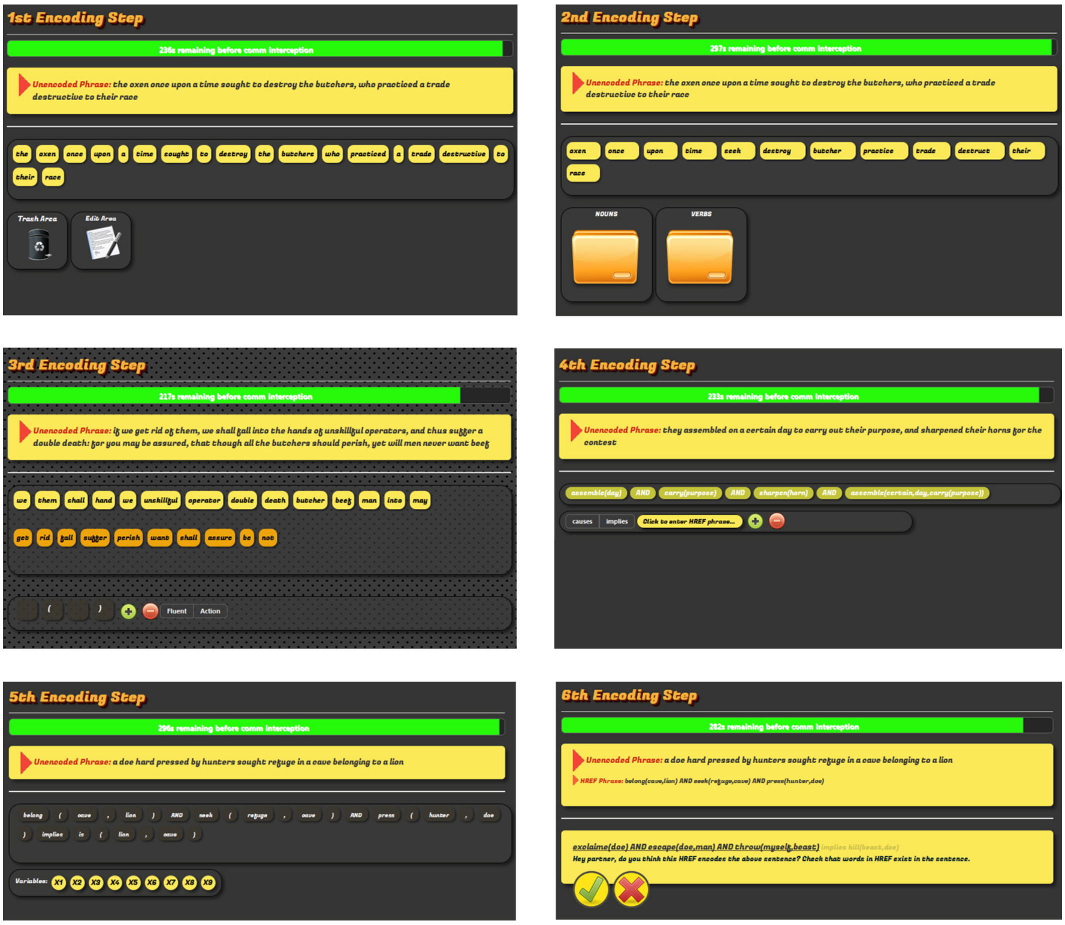

Figure 1 Screenshots of the six game missions in the 'Knowledge Coder' game.

After all six steps are completed, the resulting background knowledge comprises those rules that have been found to be sufficiently applicable and sufficiently validated.

4 Crowdsourcing through a GWAP

The proposed methodology implicitly assumes that human participants are knowledgable, honest and willing to participate. Since these assumptions might not necessarily hold in practice, certain measures need to be taken to counter the possibly negative effects of the actions of less knowledgable or honest participants. One such measure is already present in the methodology. The multiple steps it comprises reduce the possibility of user error and the complexity for novice human participants, allow for easier control of the outcomes of each step, and facilitate the integration with knowledge understanding systems.

We adopt the use of GWAPs for the crowdsourcing of knowledge acquisition as a way of motivating people to participate [34]. Our developed game is called 'Knowledge Coder' (see Figure 1) and a prototype version is accessible online at: `http://cognition.ouc.ac.cy/narrative`.

Our approach falls into the output-agreement games template [34], requiring players to agree on the same output they produce. The game follows closely the methodology described in the previous section, with each step corresponding to a 'mission' in the game.

The game story takes place in the near future, where planet Earth is captured by alien forces capable of intercepting human communications in natural language. Players are asked to join the resistance forces and help their co-defenders encode human knowledge in a structured form that is not readable by aliens, and thus guard it from being intercepted.

Players are introduced to a game environment containing a mission instructions area, a time countdown bar, a high scores area, and an active mission area. Players also have access to mission specific instructions and online help during game play.

As with other games, players are encouraged to play using competitive motives [10]. For each successful mission attempt, players are rewarded with points that are added to their total score. Players are also rewarded with extra points when other players contribute and verify the former players' mission results and vice versa. These extra points are used to separate the knowledgeable and honest players from the rest. After a player reaches a certain score, an award is issued and added to the player's profile. These methods are commonly applied techniques to encourage and promote competition among players in games [15].

A common problem in online games is cheating through, for instance, communication between players outside the game [24]. To reduce such effects, missions are time-bounded to prevent players from using external help to complete them. The anonymity of players is pursued and no contact details are made available throughout the game play. Also, each player's Internet address is recorded and associated with each attempt on a mission, so that individual players masquerading as two or more different players are detected and are filtered out. Finally, every mission is initiated with a random sentence, so that the probability of two players attempting to work on the same instance of a task is minimized.

Players can provide feedback through the game interface. Feedback submitted is valuable both for debugging purposes and for further game development. Players can request new features, changes to the user interface, or extra missions, or suggest improvements.

5 Empirical Setting and Results

For our initial empirical evaluation of the game we prepared an evaluation process using a small group of people and two stories loaded into the game. Both chosen stories were short and used simple English words. For the purposes of this evaluation we selected two Aesop Fables: 'The Oxen and the Butchers' and 'The Doe and the Lion' [32].

Five participants were trained on how to play the game on a test deployment of the game. This group included both men and women aged eighteen and above, all with a high school education, and with some of them enrolled in a university. All missions were presented and each player had the opportunity to familiarize themselves with the look and feel of the game. For the purposes of the experiment, each player created a game account. The game was available for one week, at the end of which each player was asked to complete a questionnaire. All knowledge gathered was analyzed, and our conclusions are presented below.

5.1 Analysis of Results

We collected approximately one hundred user-generated rules; Table 1 presents some relevant information. Below we present and discuss a sample of the collected rules.

```
R1: horn(X) and assemble(X) and carry(purpose) and sharpen(X) and
    assemble(certain,X,carry(purpose)) implies have(ox,horns)
```

```
R2: assemble(day) and carry(purpose) and sharpen(horn) and
    assemble(certain,day,carry(purpose)) implies prepare(ox,war)
```

Table 1 Relevant information from the experimental deployment of the 'Knowledge Coder' game.

Number of stories	2
Number of sentences	7
Number of players	5

Number of rules generated	93
Number of causality rules	15
Number of implication rules	78

```
R3: beast(X) and throw(Y,mouth,X) implies kill(X,Y)
```

```
R4: beast(X) and man(Y) and doe(Z) and exclaime(Z) and
    escape(Z,Y) and throw(Z,X) implies kill(X,Z)
```

As one can observe, rules R1 and R2 are too specific and tightly coupled to the story used to generate them ('The Oxen and the Butchers'). This level of specificity is inappropriate for gathering broad background knowledge. The metric of applicability can be used to filter such rules out. By requiring rules with high applicability, we are more likely to end up with rules like rule R3 which can be usefully applied in almost any story with wild animals. The fact that the majority of the rules produced by the first five steps of our methodology did not receive a high applicability score during the sixth step, suggests the need for an additional incentive in the game so that players produce simpler and more general rules. Such an incentive, for example, would allow players to suggest the deletion of predicates man(Y), doe(Z), exclaime(Z) and escape(Z,Y), from rule R4 to produce a rule similar to rule R3.

Note that rule R4 includes a misspelled predicate name (i.e., 'exclaime' instead of 'exclaim'), demonstrating that output-agreement does not guarantee that the gathered knowledge is error-free, and that additional incentives might be needed to reduce such errors.

5.2 Player Feedback

After completing the game, each player was asked to complete a questionnaire for assessing the game design, concept, usability, enjoyment and other factors such as playing time, game scoring, etc. Feedback was also requested on how well players understood the instructions given for each mission and the time needed for them to comprehend them before starting playing. Finally, players were asked whether missions are relevant to the game concept and what they would like to see changed for the game to become more engaging.

By analyzing this feedback we conclude that players found the game story interesting and that they would be willing to advertise the game to their friends. Most players found the first two missions (i.e., 'sentence processing' and 'verb and noun identification') easy to play and the instructions given informative. For the next two missions (i.e., 'predicate construction' and 'rule construction'), players seemed to require some time before understanding fully what they were expected to do. These two missions were also characterized as the most interesting ones and kept players engaged throughout the game play.

Four out of five responders characterized the fifth mission (i.e., 'rule generalization') as not very challenging, since they understood that they only had to replace arguments with variables. On the one hand, this feedback suggests a misunderstanding on the part of the players on what they were expected to do, which can be avoided by improving the mission instructions. On the other hand, this feedback is in line with the acquisition of not highly applicable rules, which suggests the need for stronger incentives to simplify the rules.

Several of the comments received concerned the creation of a tablet and mobile version of the game and integration with social media for posting score to the players' friends and contacts. One responder suggested that more languages should be available for the game.

6 Conclusion and Future Work

Designing an engine that can handle broad background knowledge for story understanding is far from being a trivial task, due to the fact that this knowledge is not given explicitly in the actual story text. In this paper we have presented our initial work on developing a crowdsourced solution to the problem of acquiring such knowledge directly from humans. The background knowledge gathered from our developed game offers some initial encouraging results in terms of the feasibility of our methodology. With improved instructions and incentives we expect to address the problem with the acquisition of highly applicable rules.

We could also explore different paths in the methodology used. Instead of using the Event Calculus, we could consider using the Situation Calculus [3] for representing the acquired knowledge without the need to reference particular time-points. An important enhancement to our methodology would be the addition of an extra step to denote preferences among pairs of rules with conflicting heads. This should also be reflected in the game in the form of an extra mission, after the currently last mission of 'rule evaluation'.

As part of our ongoing work we are implementing these and other improvements suggested by the user feedback that we have received, and plan to deploy the 'Knowledge Coder' game to gather background knowledge and conduct further experiments with more stories and players. A reasoning module will be integrated with the knowledge acquisition module to reason with the acquired knowledge on new unseen stories, offering a means to evaluate the acquired knowledge on the task of interest itself: understanding stories. In particular, we plan to integrate the framework of Diakidoy et al. [7, 8], which has been developed based on psychologically-validated models of narrative comprehension, and whose formal representation of stories and background knowledge closely matches the representation used in our work. Finally, we plan to compare our fully-crowdsourced solution against automated or semi-automated ones for acquiring background knowledge.

Although our work has centered on the task of knowledge acquisition for story understanding, we believe that our methodology is applicable more generally, and can find use in other lines of research that assume as given commonsense knowledge in a structured form.

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Where Story and Media Meet: Computer Generation of Narrative Discourse

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Abstract

Story generation (including interactive narrative) consists of creating a narrative experience on computer by generating narrative events. It requires building an abstract computational model that can generate a variety of narrative events from a limited set of authored content. These models implement a *story logic*, as they formalize the occurrence of an event in the story according to various algorithms. At the same time, these stories aim to be expressed to an audience using digital media, which requires a *medium logic*. In this contribution, we look at the relation between story logic and medium logic in the production of mediated narrative discourse. Using the terminology of Russian formalists and a metaphor borrowed from cinema production, we introduce three models of increasing complexity. In the first model, the story logic (fabulist) creates a fabula which is performed by the medium logic (director) to a screenplay then to the screen. In the second model, the story logic (screenwriter) generates a sjuzhet composed of narrative discourse acts that are staged by the medium logic (director). In the third model, the story and medium logics communicate bidirectionally as co-authors of the screenplay in order to render the story optimally.

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1 Introduction

The domain of story generation covers a variety of computational techniques aiming at generating events that constitute a narrative. Within this paper, we will adopt a large acceptation of the term, that ranges from the generation of a text in a basic language, to the generation of pleasing aesthetic experiences, in text or visual media. We also include research in interactive digital storytelling which makes use of generative algorithms to adapt the story to the user's choices. The common feature of these techniques is that they require building an abstract computational model, that will be able to generate a variety of narrative events from a limited set of authored data. These models implement a *story logic*, as they formalize the occurrence of an event in the story according to various rules and algorithms. Depending on systems, this story logic can be based on the simulation of characters [6, 2], the simulation of reader's response [35, 3], the simulation of narrative acts [27, 30], etc. For this modeling task, there exists a vast set of narrative theories, in particular within the formalist approach (Propp, Bremond, Greimas).

At the same time, these stories aim to be expressed to an audience: the reader, the viewer, the listener, the user, depending on a specific medium. To represent a generated abstract

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story event within a certain medium requires another kind of theory. For text for example, the computational linguistics technique known as *surface realisation* generates appropriate sentences from abstract clauses. Furthermore, an effective text generation system must also include a model of style and perform paraphrases to avoid monotonic language. Generating stories to different media such as 2-D or 3-D animation requires similar generative theories.

Previous work in story generation has adopted, implicitly or explicitly, a simple communication model between story and medium: the pipeline model. Practically, it consists in taking the output of the story logic part, expressed as a series of actions or events, and feeding them to the medium logic. This approach has the advantage of simplicity but it raises two issues. On the one hand, the medium logic possesses limited information from the story logic and performs an uninformed flat representation of story events. On the other hand, the story logic does not take into account the strengths and limitations of the medium. To resolve those issues, what is missing is a theory describing the interrelation between the story and the medium. In this paper, we lay the ground for such a theory by offering a review of previous work and proposing three models with increasing complexity.

2 Story and medium in narrative theories

The relation between the narrative and the medium is an old debate in narrative theories. Narratology as a discipline has emerged in the 1960s as a study of narrative structures that are independent of the medium [25]. For example, C. Bremond analyzes Propp's approach by stating that the structure of the story is independent of the techniques that carry it [5]. This independence is illustrated by the theory of G. Genette [11], which states that a narrative is composed of three distinct layers: the **story** consisting of events arranged in the temporal order within the fictional world; the **discourse** consisting of events re-organized in the temporal order in which they are presented to the audience; and the **narration**, which is the act of narrating a story and the concrete situation in which the story is conveyed through a physical medium. This tripartite model finds its roots in Russian formalism, via the fabula/sjuzhet distinction. (Note on that respect that one must remain careful with the terms coming from different narrative traditions and their translation between Russian, French and English). By adopting the working hypothesis that the story is independent from the other layers, theorists have produced several useful semi-formal models of the story [5, 12, 32].

Nevertheless, the hypothesis that narrative can be described independently of the medium has been largely criticized in the theories of narrative: *critics have been adamant that form does not separate from content* [8]. According to many theorists, it is not possible to translate a story from one medium (e.g. a book) to another medium (e.g. film) without changing the story itself. Furthermore, the characteristics of a medium determines, as a resource, which stories can be told in that medium [16]. Between these two opposite positions (the thesis and the anti-thesis), Herman proposes that a synthesis is possible [16]. It consists in considering that the medium dependence of stories is a matter of degree. In this paper, we adopt Herman's position, that is, we acknowledge the three layers from Genette's theory, but we also question, from a computational point of view, what it means that some feature more or less translate across media. We will use the following concepts and terminology:

- **Event**: an elementary modification of the fictional world. Events include actions and happenings [24]
- **Fabula**: the set of events occuring in a narrative along with their temporal relations within the fictional world.

- **Discourse**: the set of events in the fabula along with their temporal relations within the narrative experience time.
- **Mediated discourse (rendered story)**: the physical representation of the subset of events that are effectively displayed in a given medium.

Literary text is the implicit medium in many theories of narrative, including Genette's theory. It has some specific features that constrains the type of narrative it can support: it is based on a complex written language; it is mono-modal (reading); it is sequential. In contrast, it is worth observing how cinema differs from literary text, and how it calls for a different account of the relation between fabula, discourse and mediated discourse [19]. The computer medium, used in games and interactive storytelling works, albeit sharing properties with cinema provide yet another range of characteristics regarding the above-mentioned relation. In the rest of the paper, although 3-D virtual worlds are targeted in the short term, we will apply the above-defined narrative concepts generally to arbitrary media.

3 Story and medium in digital narrative

For more than 30 years, research has been carried out in the fields of interactive fiction, interactive narrative and interactive drama to produce computer-generated stories in different media: text, as well as 2-D and 3-D graphics. In this section, we want to explore how the resulting prototypes handle the relation between the fabula, the discourse and the rendered story. Because some of these systems have explicitly used narrative theories, we will also explore how they have interpreted Genette's theory and other narrative models. Six cases will be discussed and contrasted, that represent (but do not pretend to cover) the state of the art in the domain.

FearNot! [1] is an interactive drama prototype based on the simulation of autonomous agents. Agents use a complex and emotional architecture to generate actions dynamically, according to the current situation that may be influenced by the user. In this generative system, the visualization in a 3-D game engine is clearly separated from the characters' logic [2]. The actions themselves are completed with information regarding the way the action must be performed (e.g. facial animation). Because the outcome of the action depends on the physical configuration, this outcome is decided in the visualisation engine that sends this information back to the logical part of the system. "FearNot!" implements a bipartite model with a strong independence between the two parts.

The Mutiny. [31] is a text-based interactive drama based on the IDtension system [30]. Narrative actions inspired by Todorov [32] are simulated and selected according to narrative criteria such as conflict or complexity. Once calculated in the narrative engine itself, fabula events and possible user choices are sent to another module that displays events as text and proposes choices via a specific menu system. Similarly to "FearNot!", there is no separate discourse layer. However, the rendering layer does not render all events: it only renders events that involve the user, while others are logically executed but not displayed. As a result, the user may convey an information to character A, and then receive a comment on this information from character C because, in between, A talked to C. Therefore the visualisation module carries out some of the functions of the discourse layer.

Nothing For Dinner. [13] is also based on IDtension, but within a 3-D environment. It therefore demonstrates the advantage of medium independence in terms of interoperability.

The same story can be displayed in text or in 3-D [29]. As for Mutiny, the rendering filters out some actions: some NPC actions may not been seen by the user, depending on her position and orientation in the 3-D environment. Note however that this visibility is not sent back to the narrative engine. In conclusion, the visualization engine in "Nothing For Dinner" plays a role at the discourse level, but this role is not necessarily controlled narratively.

Prom Week. [18] is a Facebook game, based on a large set of rules simulating the social relations between high school students. In terms of visualization, fabula events are displayed, without specific discourse processing. In order to avoid the Tale-Spin effect [34] that occurs when complex internal information behind characters' actions are unfortunately hidden, the cartoon-based rendering is supplemented with an explicit display of internal features of characters: how they feel, how they relate to each other, their status, etc., as in video games such as "Creatures" or "The Sims". Therefore, the discourse layer is rich and expressive, compared to other systems discussed here, but the expressivity relies on an analytic reading of internal numbers rather on the intuitive perception of the characters' behaviors.

Suspenser. [7] is a module in a larger architecture that aims at generating suspenseful stories. This whole architecture is directly inspired from Genette's approach (adopting the Russian terminology). Three main modules are considered: the Fabula Generator (producing the fabula), the Suspenser (transforming the fabula into the sjuzhet) and the Discourse Generator (transforming the sjuzjet into the medium). The main innovation of this research is to explicitly tackle the transformation of the story into discourse (note a shift in terminology, discourse here corresponds to the mediated discourse in our terms). Suspenser is able to automatically re-order events in the fabula to create a more suspenseful ordering of events. But Suspenser does not take into account the specificities of the medium, and the re-ordered events are handled by the Discourse Generator in a traditional pipeline approach.

Slant. is a system for story generation [21] that integrates five components from three different systems. These components include: MEXICA that generates plots; Fig-S that generate variation of the plot by using metaphors; Verso that adds constraints regarding the genre; GRIOT-Gen that realizes metaphorical representations and Curveship-Gen that generates the text. The distinctive feature of Slant is that it goes beond the pipeline approach that characterizes all previous cases. Via a blackboard approach, the chain of processing is not always unidirectional. In particular, Verso can intervene after MEXICA by adding a new action to the plot and this action is in turn processed by MEXICA. Note however that these bottom-up processes are used for building the plot (corresponding to fabula in our terminology), not for building the medium-specific discourse.

These six cases obviously do not cover all the field and many other cases would deserve a similar discussion, but this sampling is sufficient to formulate the following general observations:

- All systems more or less follow the general principle of independence between narrative layers.
- The separation between layers in not uniform across systems. In particular, for systems which are bipartite and not tripartie, the discourse layer may be dispatched in both modules.
- What is conveyed from the story logic to the discourse and/or medium logic(s) varies among systems: from the mere ordered set of events to much more complex engine-specific structures, making interoperability between different systems difficult.

In order to progress towards a computational model of story/medium relation, we propose to focus our attention on the data that may circulate between story, discourse and medium modules. In order to restrict our scope to the simplest case, even if it departs from a pure Genettian approach, we will only consider two modules. While this may appear limited in scope, this configuration is already sufficiently rich to open many new possibilities in terms of narrative expressivity, as it will be detailed in the next sections.

If a model of story/medium relation is to reach a certain level of generality, the data that circulate between these two modules should be independent both from a specific narrative generation approach and from a specific medium. As a result, the data should not refer to *plans, speech acts or cases* specific to a particular story logic and neither should they refer to *verses, cameras or panels* specific to a particular medium. The language used to communicate between story and medium should be neutral and yet expressive. We consider this language as a *lingua franca*, defined as "a language systematically (as opposed to occasionally, or casually) used to make communication possible between people not sharing a mother tongue, in particular when it is a third language, distinct from both mother tongues" (Wikipedia).

In the next three sections, we will propose three successive specifications of a lingua franca between story and medium. They correspond to three options that may be adopted when designing a whole system for story generation, including the interactive storytelling case. These models are of increasing complexity, meaning that the first one is a special case of the second one which is a special case of the third one. Therefore the last model is the most sophisticated one.

4 The fabulist-director model

As described in the previous section, a common approach in most state-of-the-art systems is a pipeline model, where the story logic creates fabula events and sends them to the medium logic. In case of a 3-D medium, virtual actors play those events in real-time 3-D animation, and a cinematography module chooses camera viewpoints and displays them to the audience. Let us call this the *fabulist and director* model. The model has several advantages - it works and it is simple. Although we have already stressed its limitations, it is important enough to be reviewed in detail.

The core information needed to describe the fabula is the succession of events that happen in the fictional world. Therefore, **events** constitute the first elements in the lingua franca. Following the traditional distinction in narratology [15, 24] an event may be either an action, in which case it involves an agent, or a happening, in which case no agent is causing the event. Events are usually described in a predicative form, where the predicate represent the class of event (expressed as a verb) and the parameters are role-value pairs such as **(agent,character)** in the case of an action. Other roles may take values from other elements: characters, objects, places, and events (in which case the events are nested). Therefore the lingua franca also include characters, objects and places, which are called existents [24].

Temporal relations between events can be described either implicitly or explicitly by providing a start time and a duration for each event. In a temporal medium, the unfolding of a single event may take an unpredictable amount of time. Moreover, in some media, like interactive 3-D environments, the event may fail. Therefore, the medium needs to send back the information that the event is finished (**eventFeedback**), and the corresponding outcome, in terms of success or failure.

Finally, the interactive case needs to be examined, regarding the lingua franca. There exists a large variety of interaction modes in the field of interactive storytelling but what

Table 1 Elements of the lingua franca for the fabulist-director model.

Name	Constituent's name	Constituent's description	Direction
event	eventType	action|happening	Story→media
	content	predicate structure : P(a1, a2, ..., an)	
	indication	various formats	
	status	execution|user-possible	
	id	unique integer	
eventFeedback	result	success|failure|user-decided	Media→story
	id	unique integer	
UserEvent	eventType	action|happening	Media→story
	content	predicate structure : P(a1, a2, ..., an)	

is exchanged with the story module still consists of events. However, these events must be enriched with additional data. First, the story module needs to be able to send *possible* actions, the execution of which depending on the user's choice. Second, in return, the medium logic needs to inform the story logic that an action has been chosen. Therefore, in the lingua franca, the action is enriched with a **status** attribute, that can take three values: execution, user-possible, user-decided. Also, the lingua franca includes the case where the user is creating events that have not been proposed by the fabulist. Therefore, a **userEvent** element is introduced.

Table 1 summarizes the lingua franca related to the fabulist-director model. As already mentioned, this model is not new *per se* but illustrates one simple approach of story/medium relation, in which the story logic (fabulist) produces a raw description of actions that must be conveyed to the user by the medium logic (director). In the medium of text for example, the director generates a natural language version of the predicate-based content. Similarly, in the medium of 3-D animation, the director generates character animation, cinematography and film editing in real time [22].

The fabulist-director model has severe shortcomings. The director receives very little information from the fabulist to motivate directing choices: Is the event important or anecdotal? What emotion does it convey? How does it relate to previous events? Without answers to these questions, the director has no other option than to use standard, repetitive options. In the fabulist-director approach, the director's role is limited to showing events in the fabula in chronological order and with a neutral point of view. With such a minimalist approach, it may be difficult or even impossible to show all events to the viewer. To make things worse, the director has no way of reporting that some events could not be shown to the viewer, which may cause the following steps in the story to become unintelligible.

5 The screenwriter-director model

To overcome the limitations of the previous model, it appears necessary to revise the role of the story logic. Instead of simply reporting fabula events, we now require that the story module communicates towards an audience, taking charge of (part of) the narrative discourse. By analogy with film, this transforms the fabulist to a screenwriter. Indeed in traditional movie-making, it is a common practice to write an intermediate document – the screenplay – that represents events as they will appear in the movie (not the fabula) and from the point of view of the audience. Narratologically speaking, the screenplay is an interesting document, since it represents the narrative discourse in plain words, but with the temporal and spatial structure of a movie (scenes are indicated to represent spatial and temporal changes). However, our model departs from the film analogy by further imposing that the screenplay be medium-independent.

Based on the above observations, we propose a different model of story-medium relation where the story logic is not limited to creating fabula events, but also produces a narrative discourse as a series of *discourse acts*. In such discourse acts, the subject is the computer and the object is the audience. In our proposal, the screenplay is not written in natural language (as in a real screenplay) but as a conceptual representation of narrative discourse acts.

The main discourse act at work in a fictional discourse is **CONVEY** that simply consists of conveying information about the story world to the player. Because the story world is fictional, the narrative discourse act of conveying a state or attitude or event in the story world can best be compared to the speech act of pretending – which in Searle's theory is the core component of fiction [26].

The first difference with the fabulist-director model is that the screenwriter can now specifically choose the ordering of events. The following steps will further extend the model with typical discourse-related information. The first extension concerns states in the fabula. In the fabulist-director model, states in the fabula (object properties, mental states, etc.) are not communicated to the director, which is purely event-based. In the screenwriter-director model, the screenwriter may decide to convey, at a precise moment, a current state. For example, it can choose to convey the emotion of the character John: fear, just before this character attempts a dangerous action. Depending on the medium, this information may be displayed differently. A director in the text medium may generate a sentence such as "John was terrified". A director in the 3-D animation medium may insert a close shot on John with the proper facial expression; or shake the camera or trigger a fearful music; etc.

In complement to $CONVEY$ discourse acts, narrative information can be added, in order to provide information on the manner to represent the action or happening. It includes the type of emotions that the event is expected to cause in the audience, the relation to other past or current events, the relation to characters and objects in the scene, the opening or closing of a subplot, etc. We therefore include a narrative **indication** field to the discourse act, letting it open what kind of information may be included in this field.

Another dimension of a discourse act is its relative importance of the event. Key actions, such as Barthes' kernel functions [4], need to be represented with a specific focus. In film for example, the Hitchcock principle says that the size of an object that is currently in the frame should be related to its importance at that given moment [33]. Therefore, the model adds an **importance** field to the discourse act **CONVEY**.

Regarding events ordering, major discourse-related processing such as flashbacks or flashforwards are processed (if any) by the screenwriter. However, the director may need some flexibility regarding the precise ordering of some overlapping events, both at the fabula

Table 2 Elements of the lingua franca for the screenwriter-director model.

Name	Constituent's name	Constituent's description	Direction
CONVEY	contentType	action|happening|existent|state	Story→media
	content	predicate structure : P(a1, a2, ..., an) or simple proposition for existents	
	indication	various formats	
	importance	in [0,1]	
	priority	in [0,1]	
	perceivedBy	list of characters	
	pointOfView	a character or an object	
NOT-CONVEY	contentType	action|happening	Story→media
	content	predicate structure : P(a1, a2, ..., an)	
	priority	in [0,1]	
	notPerceivedBy	list of characters	
CONVEY-FALSE	contentType	action|happening|existent|state	Story→media
	content	predicate structure : P(a1, a2, ..., an) or simple proposition for existents	
	indication	various formats	
	importance	in [0,1]	
	priority	in [0,1]	
	perceivedFalseBy	list of characters	
	pointOfView	a character or an object	
PROPOSE-EVENTS	choiceList	list of events with corresponding id and attributes	Story→media
ENCOURAGE/ DISCOURAGE	eventType	action|happening	Story→media
	content	predicate structure : P(a1, a2, ..., an)	
eventFeedback	result	success|failure|user-decided	Media→story
	id	unique integer	
UserEvent	eventType	action|happening	Media→ story

and at the discourse level. For example, if Mary asks John for help for lifting a heavy box, the following event should occur immediately. But the decision of a third character Lucy to suddenly stand up to and walk to the fridge may occur now, or slightly later, without any significant change in the narrative. In some media, such as 3-D animation, such secondary action by Lucy may get in the way of the primary action involving John and Mary. This can be remedied by letting the screenwriter assign a **priority** indication to the discourse act **CONVEY**.

In addition to the **CONVEY** operator, it should be possible for the screenwriter to give indications that some fabula events should remain hidden from the player. We propose the operator **NOT-CONVEY**, meaning that a fabula event is taking place but hidden from the player until further notice. **NOT-CONVEY** is not equivalent to an empty act, because the event *does* occur in the fabula, and the director must ensure that the event is not be perceived by the audience. For example, in a 3-D environment, if the director receives the information of not conveying the action of John lifting a box, it must ensure that the camera never displays the box and John lifting it. Interestingly, at the narrative level, this discourse act opens the way to decide later if the event happened or not, a strategy called late commitment [28], that allows for more flexibility in the narrative generation, especially in an interactive context.

A more radical discourse act **CONVEY-FALSE** can be used to lead the audience to believe that some fabula event is happening, whereas it is in fact not the case. In some extreme cases, this may lead the director to lie to the audience, as in the 1995 movie Usual Suspect, by Bryan Singer, i.e. show events that did not take place in the fabula. In many cases, the same effect can be produced by providing only partial information from which the audience can draw false inferences. This creates an interesting twist when the audience then discovers what finally did "really" happen in the fabula. Such an effect is subtle to render and, once again, is rendered differently by different media. In the 2011 movie "The Artist", a modern silent movie by M. Hazanavicius, the main character is about to commit suicide, when an intertitle with the word *bang* is displayed. While this seems to indicate that the character has shot himself, the next shot shows a car crashed against a tree! In this case, the effect is used for only a few seconds. In other examples, the wrong belief may last during the entire duration of the story.

An extension of the **NOT-CONVEY** discourse act concerns the characters rather than the audience. The screenwriter may wish to control which characters perceive the conveyed event. For example, it may specify that John is lifting a box but that Lucy is not aware of it. This applies for both **CONVEY** and **CONVEY-FALSE**. In the model, these discourse act are supplemented with a **perceivedBy** field that contains one or more characters and their perception constraints (must perceive or must not perceive).

Another very important discourse-related information is *point of view.* The screenwriter may decide that an event must be presented to the audience from a given perspective. This can be one of the participants in the event, or any other character known to perceive the event. In text generation, the "Curveship" system is able to change the point of view (who sees) as well as the narrator (who speaks) [20]. In 3-D environments, point of view is an important consideration for choosing camera angles [23]. Our model therefore includes an optional **pointOfView** field that can contain characters or even objects.

Finally, we introduces three additional narrative discourse acts to allow direct interaction with the audience:

- **PROPOSE-EVENTS**: The screenwriter proposes a list of possible events that the audience can choose from. Typically, in the case of interactive drama, it will include all

actions from the user-controlled character. To each proposed event is attached one or more attributes that we de not specify at this level and that qualifies the choice. For example, the estimated suitability of playing this action at this moment may be provided, allowing the director to highlight the most suitable choices.
- **ENCOURAGE**: Although interactivity is about giving choices to the user, it may be suitable in some context to influence the user towards a specific choice. Strategies of this kind have been suggested by researchers [35, 10]. Interestingly, there is a mirror effect in this case between the discourse and the diegesis (fictional world), when an influence from a character serves the purpose of the enunciative instance.
- **DISCOURAGE**: It is the opposite of the previous act: influencing the user so that she does not choose a given event.

Table 2 summarizes the lingua franca for the screenwriter-director model. We do not believe that we have exhausted this configuration, yet, the model appears very rich compared to previous work. By no means do we recommend that a system implementing this lingua franca should be developed right away. The lingua franca should rather serve as an overview of the range of options that the screenwriter-director model offers, from which a system designer may pick whatever features appear relevant.

6 The co-authors model

In this section, we propose a model that better accounts for the two-way relations between story and medium. The model builds upon the screenwriter and director model of the previous section, but adds back-channel communication from the director to the screenwriter.

The model considers that the story and the medium are two authors, collaborating to create a mediated narrative experience. To draw an analogy with film-making, it corresponds to the situation in which the screenplay is modified and re-written on the set, which is often the case in film production [9, 14]. The story logic is still in the position of generating discourse acts but the medium logic is now allowed to confirm, infirm and suggest narrative discourse acts as well. More precisely, rather than return success or failure, the medium can now send feedback in one of two forms:

- In case of success, the medium logic may execute a discourse act that is slightly different from the requested act. For example, the act conveyed an event as requested but with different parameters. The medium logic produces the best effort to execute the requested act but does not guarantee that the event is represented exactly as requested. For that purpose, a new discourse act is introduced, **CONFIRM**, which includes the details of how the the content has been effectively represented. Note that the medium logic has to make a decision wether the alternative discourse act is still acceptable or wether a failure return should be preferred (next case).
- In case of failure, and if it is possible to do so, the medium logic proposes an alternative discourse act that it could execute, that contains the same event or existent, but with different surrounding fields. For example, it may suggest to relax the constraint of perception (**perceivedBy**) by allowing a character to perceive the action. The corresponding discourse act is **INFIRM**, which contains (optionally) a new set of values for the fields of **importance, priority, perceivedBy** or **pointOfView**.

In the above case, the medium logic is *reactive* when it proposes an alternative act following an impossibility to perform the desired act. It can also be *proactive*, by suggesting events. For example, in a 3-D environment, the director may suggest that the current spatial configuration of four characters into two groups of two would be suitable for conveying two simultaneous events with these two respective groups, one with a dialog, the other

Table 3 Elements of the lingua franca for the co-authors model. These elements, covering the medium to story communication, come in addition to the story to medium communication elements in the screenwriter-director model (see Table 2).

Name	Constituent's name	Constituent's description	Direction
CONFIRM	id	unique integer	Media→story
	indication	various formats	
	importance	in [0,1]	
	priority	in [0,1]	
	PerceivedBy/ perceivedFalseBy	list of characters	
	pointOfView	a character or an object	
INFIRM	id	unique integer	Media→story
	indication	various formats	
	importance	in [0,1]	
	priority	in [0,1]	
	PerceivedBy/ perceivedFalseBy	list of characters	
	pointOfView	a character or an object	
SUGGEST	contentType	action|happening|existent| state	Media→story
	constraints	include list and exclude list of existants and states	
	indication	various formats	
	importance	in [0,1]	
	priority	in [0,1]	
	perceivedFalseBy	list of characters	
	pointOfView	a character or an object	

without. It could also suggest that an ominous representation of a given character would be particularly suited at this moment (say with a low-angle shooting and a backlighting). Therefore, we introduce the discourse act of **SUGGEST**, containing the specification of fields characterising an event.

Table 3 summarizes the three narrative discourse acts introduced above, which come in addition to those already present in the screenwriter-director model (they replace the last two lines in Table 2). The negotiation mechanism involved between the two "co-authors" is beyond the scope of the present paper. Our focus remains on the lingua franca which now involves nine narrative discourse acts.

7 Conclusion

In this paper, we have proposed the first steps of a computational model of narrative that zooms out from the logic of story events to encompass the whole picture of narrative as an expressive artefact, embodied in a medium. This has led us to focus on how the story logic and the medium logic need to converse, and to propose three models of what we have called the lingua franca between the story and the medium. Our current effort goes towards the practical implementation of a small version of the above-described lingua franca, by connecting interactive narrative technology [30] with virtual cinematography technology [17] in a principled way.

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A Cognitive Approach to Narrative Planning with Believable Characters*

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Abstract

In this work, we address the question of generating understandable narratives using a cognitive approach. The requirements of cognitive plausibility are presented. Then an abduction-based cognitive model of the human deliberative reasoning ability is presented. We believe that implementing such a procedure in a narrative context to generate plans would increase the chances that the characters will be perceived as believable. Our suggestion is that the use of a deliberative reasoning procedure can be used as a basis of several strategies to generate interesting stories.

1998 ACM Subject Classification I.2.0 Artificial Intelligence – General – Cognitive Simulation

Keywords and phrases narrative planning, believability, cognitive approach, abduction

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1 Introduction

Throughout their lifetime, humans are surrounded by narratives. A large amount of time is devoted to the production of narratives [19, 13]. Many psychologists and AI researchers suggest that narratives are used to make sense of the world, to order events and assimilate them. This narrative intelligence is of major importance in the cognitive processes employed across many contexts including entertainment [10], advertising, remembering or learning [8].

The classical problem addressed in the context of narrative generation is the *fabula* generation, *i.e.* the generation of a temporally ordered sequence of events from the time the story begins to the time the story ends [1]. The process of generating a narrative meets some requirements to form acceptable narratives. One of them is to produce a sequence of events that is understandable by the audience. Events should respect the causal rules of the (possibly imaginary) world and the audience must be able to infer the characters' intentions during the course of the narration [2, 7].

In this work, we address the question of generating stories using a cognitive approach. Especially, we are interested in investigating how authors create understandable stories with believable characters. To do so, we will argue in favor of a cognitive model of deliberative reasoning to generate stories.

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2 A cognitive approach to narrative planning

Computer-based story generation has been the subject of intense study in Artificial Intelligence during the last century. The present work addresses the question of generating stories using a cognitive approach. Especially, we address the question of generating plans, *i.e.* temporally ordered sequences of actions or events.

Generating plans not only consists in choosing actions that respect the causal rules of the world but also make the characters of the story appear believable. Characters' actions should not negatively impact the audience's suspension of disbelief [2]. As Riedl and Young (2005) put it: 'one important aspect of character believability is character intentionality [*i.e.*] the way in which the choice of actions and behaviors that a character makes appears natural (and possibly rational) to external observers.'

According to classical models, someone who acts intentionally must have a desire (for an outcome) and appropriate beliefs about how her action would lead to that outcome [5]. Malle and Knobe (1997) have identified five necessary components to recognize the intentionality of an acting agent: the desire for an outcome, the beliefs that the action would lead to this outcome, the intention to perform the action, the awareness of the act while performing it, and a sufficient degree of skill to perform the action reliably. In the field of automatic narrative generation, it has been shown that the characters' behavior must be perceived as goal-oriented to make them appear as believable [17]. However, not all goal-oriented systems meet the conditions of cognitive plausibility.

In the field of automatic story generation, there have been many attempts to generate stories using script-based models [6]. These models, however, do not constitute as such a cognitive approach. Humans use scripted plans to perform a large variety of tasks in daily life, like drinking water or going to the bakery. However, a story generation system should be able to modify scripts on the fly and, in the absence of appropriate scripts, to design a new plan using knowledge about the world (*e.g.* states and rules).

It has been previously mentioned that goal-oriented systems are considered as essential to make characters appear as believable. However, from a cognitive point of view, we do not suppose that humans permanently hold in mind a (potentially unlimited) set of goals that have to be fulfilled. A cognitively plausible model of plan generation at the agent's level should rather generate plans, not from some list of pre-existing goals, but on the fly, based on conflicting elements in the characters' internal knowledge and desires.

Another requirement for a cognitive model of planning is that it should not have access to an external oracle that would provide pieces of information about the truth value of some propositions. Plans are designed by the characters, from their own point of view, using only their own internal knowledge and preferences.

Cognitive models of planning have to realize a sequential computation of the plans. Many studies in psychology suggest that humans engage in something akin to partial-order planning [15]. Especially, partial-order planning systems construct plans by manipulating partial plans and revoking (if necessary) only parts of the global plan. Humans seems to exhibit performances that are close to those of partial-order planners in terms of calculation time or number of operations.

Lastly, a cognitive model of planning is not expected to generate an optimal plan that would be best evaluated (depending on various objectives). It is expected to generate plans that are merely acceptable.

In the next section, we present an abduction-based model of deliberative reasoning: the Conflict-Abduction-Negation (CAN) procedure [3]. We show that this model may be used as a cognitively plausible model for the generation of plans at the character level. We also indicate how it can serve as basis for several strategies to elicit interest in the audience.

3 The CAN-procedure, an argumentative model for narrative generation

The CAN-procedure [3] is based on the conflict resolution via abduction. It has been shown that abduction is central to human intelligence [9], especially in problem solving and diagnosis reasoning contexts [11]. In the sense close to Peirce's definition, abduction consists in generating an hypothesis that explains an observation. Abduction also plays a major role in narratives, both for characters and audience [4]. Oatley and Johnson-Laird (1987) explain how readers of a narrative feel emotions as abductions. Abduction is also a way to avoid emotional or narrative inconsistencies, and it is useful to avoid characters' goals that would appear as unmotivated.

The CAN-procedure is not goal-oriented, but problem-oriented: goals are generated on the fly from cognitive conflicts when these conflicts are detected. The output of the CAN-procedure, as it can be observed in actions and justifications, may lead observers to perceive behaviour as goal-oriented, ignoring how "goals" have been generated. To understand the notion of cognitive conflict, we have to introduce the notion of 'evaluation' of a situation.

In real life, as in the storyworld, situations are not true or false but believed or not believed. Some situations are desired and some others are not desired. We found that for plan generation purposes, it is useful to merge beliefs and desires in a single evaluation. Situations that one wants to avoid or that one does not believe will receive a negative evaluation. Situations that are desired or believed will receive a positive evaluation. The intensity of these evaluations depends on the level of desire or confidence. A situation may receive several evaluations, it may be both believed and desired at the same time. Such a case is considered as not conflicting. If the situation is believed but not desired, then the situation is 'not comfortable' and there is a cognitive conflict.

A cognitive conflict is detected whenever a given proposition is assigned two opposite evaluations. For example, imagine that John, an adventurer, is looking for a treasure. Owning the treasure is positively evaluated. However, the same fact is negatively evaluated as well, since he knows the fact is false. The role of the deliberative reasoning procedure is to diminish the intensity of evaluation conflicts. The procedure is described below:

Algorithm 1 The Conflict-Abduction-Negation Procedure

Step 1) A conflict has been detected, i.e. a situation s receives two opposite evaluations $v_1 < 0 < v_2$. The conflict-solving procedure is launched.
Step 2) The procedure performs abduction from s, looking for a "weak" cause that would make the conflict less intense. If the evaluation of the cause is smaller than $-v_1$, the conflict is moved to the cause.
Step 3) If the abduction phase fails, v_2 is replaced by $-v_1$. Then the whole procedure starts anew from the negation of s (which is conflicting as well).
Step 4) If no solution to the conflict has been found, either one evaluation is revised or the system exits without solution.

This procedure meets the conditions of cognitive plausibility previously described. Goals are generated on the fly when undesired facts are negated. Plans are calculated using the internal evaluations of the planning individual. Moreover, the CAN-procedure is something akin partial-order planning systems. Plans are only partially re-computed when inconsistencies are detected. Consider the following example:

John wants the treasure, but didn't get it (conflict). John needs to go in the castle (abduction). The castle can be reach by going over the bridge (abduction) ...

1) ... *[The bridge is not broken] John decides to go over the bridge to reach the castle and then get the treasure (plan).*
2) ... *[The bridge is broken] John cannot change it (abduction, negation). John cannot use the bridge (failure). The castle can be reached through a longer path (abduction). John decides to use the longer path to reach the castle and then get the treasure (plan).*

The Conflict-Abduction-Negation procedure can be used recursively. It means that, if the plan calculated by a character does not terminate as anticipated for whatever reason, the character may launch the procedure anew to solve the remaining conflicts. Plans may fail for a variety of reasons. At some point during the execution, a character may realize that her knowledge about the world is erroneous, which means that one ore more propositions have received a wrong evaluation. An action which was previously considered possible can no longer be performed. A character may also realize that one or more consequences of her actions were not correctly anticipated. Either her knowledge about the world is incomplete or the consequences were just probable. Yet another possibility is the intervention of other agents that may thwart the plan (including the storyworld considered as an "agent" controlled by the author). The recursivity of the CAN procedure offers simple strategies to create situations that are surprising from a character's point of view. One strategy may be the following one: the audience is informed about a character's plan but this plan is thwarted by the occurrence of some event and both the character and the audience may be surprised.

4 Conclusion

In this paper, we have built an argument for the use of a model of deliberative reasoning in the context of story generation. Our suggestion is that it may serve as basis for a minimalist model of narrative generation.

In this article, the CAN-procedure is mainly used at the character level. With a model of the audience, we believe that it can also be used at the audience level. At the character level, the CAN-procedure may be used to compute plans characters intend to achieve. It may also be used to anticipate what an audience will imagine, depending on the information provided.

The model needs to be associated with a formal model of narrative interest. In previous works, we addressed this question and we introduced a model of narrative interest: Simplicity Theory [18]. We intend to use this model based on the notion of unexpectedness in the CAN-procedure to evaluate the situations in the storyworld and locally control the level of interest during the course of the story.

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Legal Knowledge Conveyed by Narratives: Towards a Representational Model

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Abstract

The paper investigates a representational model for narratives, aiming to facilitate the acquisition of the systematic core of stories concerning legal cases, i.e. the set of causal and temporal relationships that govern the world in which the narrated scenario takes place. At the discourse level, we consider narratives as sequences of *messages* collected in an *observation*, including descriptions of agents, of agents' behaviour and of *mechanisms* relative to physical, mental and institutional domains. At the content level, stories correspond to synchronizations of embodied *agent-roles* scripts. Following this approach, the *Pierson v Post* case is analyzed in detail and represented as a Petri net.

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1 Introduction

Legal activity provides excellent examples of the operational use of narratives, for instance in *adjudication*. The interaction between parties, witnesses, experts and judges includes narrative acts. Moreover, if the case introduces a precedent, the publication of its proceedings may be seen in itself as a narrative act, meant to inform the legal system of novelties concerning social interactions and their legal interpretation. This phenomenon reproduces at a systemic scale what happens in the daily legal practice, as legal experts usually rely on prototypical or hypothetical cases when they explain or unravel a certain legal problem.

Our objective is therefore to investigate an adequate representational model for cases (historical, hypothetical, etc.). At first sight, the domain of application is a specific class of narratives, but, in reality, it is a structural component of all narratives, related to the socio-institutional interpretation of behaviour; the approach we propose may be plausibly used as well on folk tales, mythology, etc. if the motive is to investigate possible underlying normative indications.

Background. Several models have been proposed in the literature in order to represent *stories*, introducing concepts like *story grammars* [21], *scripts* [1], *plot units* [13], *multi-level representations* [17], *doxastic preferences* [15], *story intention graphs* [9] etc. All these contributions target structural components of narratives, primarily with the intent of reproducing the in-depth knowledge mechanisms specifically behind story understanding, story generation and summarization.Although the present work can be seen as a follow-up of these contributions, our focus is slightly different.

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We are primarily targeting the knowledge involved in a certain (legal) case, taking into account the possibility of receiving different explanations of a given sequence of events, usually from different point of views, allowing to consider alternative interpretations of agents' (legal) positions and intentions. Assuming that a *story* exists in the mind of the narrator/listener, we are mostly concerned by the problem of *story acquisition*, in the sense of acquiring the interpreted content in a formal representation, eventually supported by specific diagramming tools. Rather than text annotation practices, our elicitation model has more similarity with *scenario-based modeling*, used in software engineering, e.g. [11]. This paper in particular focuses on Petri nets.[1]

Knowledge acquisition is inherently coupled with finding the right representational model for the target domain. As Lwe observes in [16], for instance, *plot units* can represent causality, but not expectation; the *doxastic preference framework*, conversely, models the second, but not the first. As we need both these features to adequately characterize social interactions, this work proposes a possible solution.

The paper proceeds as follows. The theoretical framework is introduced incrementally, starting with the narrative model (2) and with a case example of narrative. We define then the story model (3), further refined with agent-role models (4). To conclude, we briefly present the representation of the case as a Petri net (5). Discussion ends the paper.

2 The narrative model

Any *narrative* always manifests three ontological layers, present at the same time: the **discourse**, the **story** and the **conversation**.[2] They are respectively signal, meaning, and relevant components of the social context—like knowledge/intents of narrator and listener—that concur to the generation/interpretation of such act of communication. The "same" story can be reported with different discourses, because the discourse defines the order and the form (verbal and non-verbal) in which the content is provided. The specific choices of transformation from story to discourse (in generation) and from discourse to story (in interpretation) are influenced by the conversation layer.

The narrative content received by an interpreter is in the form of a sequence of *messages*, which essentially correspond to *speech acts* [22]. The complete set of messages is called *observation* and constitutes a superficial layer of meaning, reporting events, states, and possibly explicit dependencies between them, i.e. the *foreground mechanisms*. In general, the interpreter has to integrate this content with other *background* components in order to complete the model with dependencies and facts that are missing in the narration, but he recognizes as relevant to explain its occurrence.[3]

Narratives often contain characters that *tell* something. In respect to these quoted or indirect speeches, which possibly constitute *nested narratives*, the higher-level story (brought by the narrator) may include parts of their discourse and clues about their conversation layers (e.g. position, knowledge, intentions of the participants).

[1] From a wider perspective, however, we target an *integrated development environment* (IDE) accounting multiple views, and allowing an incremental refinement of the elicited content. We give a preliminary example in [25], referring to UML diagrams (Message Sequence Charts), topology diagrams, Petri nets and scripts in AgentSpeak(L), a logic programming language for cognitive agents.

[2] The introduction of *story/discourse* distinction is usually associated to the Structuralists (Barthes, Todorov, Genette, etc.). Before them, the Russian formalists (Propp, Shklovsky) used the terms *fabula/syuzhet*. For the use of the term *conversation*, see for instance Young in [27]; other authors prefer *narration*.

[3] Based on these concepts, we presented in [26] a preliminary implementation of the process of interpretation, constructed on *explanation-based argumentation*.

▶ **Example 1.** As example of narrative, we consider a well known case in Property Law and in AI & Law [6]: *Pierson v Post* (1805)[4]. The story is basically the following:

> Post was hunting a fox with a horse and hounds in a wild and uninhabited land, and was about to catch it, but Pierson, although conscious of Post's pursuit, intercepted, killed and took the animal.

Both claimed the fox, the first appeal had found for Post, but this court reverted the previous result. The different positions are expressed by two judges: Tompkins (*majority*) and Livingston (*dissent*). The first, supported by classical jurisprudence, claims that:

> Tompkins: Possession of a *fera naturae* occurs only if there is occupancy, i.e. taking physical possession. Pierson took the animal, so he owns it.

where *fera naturae* is an animal wild by nature. The second argues that:

> Livingston: If someone starts and hunts a fox with hounds in a vast and uninhabited land has a right of taking the fox on any other person who saw he was pursuing it.

Both interpretations are relevant for our purposes, and create two different stories (also in a practical sense, as they would bring about different consequences). The two judges can be seen as playing the role of two different modelers, providing different mechanisms.[5]

3 The story model

In narratology the story layer is usually called the **fabula**: "a series of logically and chronologically related events [..]" [4]. This name dates back to Propp, which, altogether with the Russian formalists, started considering each event in the story as *functional*, i.e. a part of a whole sequence, necessary to bring the narrated world from initial conditions to a certain conclusion.

Following this perspective, as first definition, we may consider the story as a chain of events (a strictly ordered set):

$$\mathcal{E} = \{e_1, e_2, ..., e_n\} \tag{1}$$

In addition, specific circumstances may be described in correspondence to the occurrence of an event. A more complete definition of story should consider the following chain:

$$C_0 \xrightarrow{e_1} C_1 \xrightarrow{e_2} ... \xrightarrow{e_n} C_n \tag{2}$$

where e_i are associated to *transitions* and C_i is a set of conditions assumed to *continue* at least until the occurrence of e_i. Amongst those continuants we find also *existents*, as characters, objects, etc.

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[4] Source text: `http://www.facstaff.bucknell.edu/kinnaman/Piersonv.htm`.

[5] In these terms, court proceedings can be seen as pushing to the public foreground institutional mechanisms not adequately defined in certain contexts. See [14] about the role of narratives in respect to *tacit* knowledge.

Plot. The definition of story given above seems quite simple, but the manifold relations between *consequence* (logical, causal) and *consecutiveness* (informed by time, ordering, verbal tense) are actually very delicate to assess. Furthermore, two different chronological coordinates coexist in a narrative: a *story-relative* time, i.e. when the event has occurred in the story, and a *discourse-relative* time, i.e. when that event has been reported/observed.

The concept of *plot* is relevant in this issue.[6] Trying to better scope the problem, we identify three *levels of constraints* on the ordering of events via the following method, first presented in [25] but hereby slightly refined:

1. We identify the events and conditions explicitly expressed in the story.
2. For each event, we identify which conditions/events in the story are direct requirement and consequence of its occurrence. If necessary, we integrate them with external knowledge. The relations elicited in this way constitute the *dependencies* (causal, logical) and place some **strong constraints** on the ordering of events.
3. Time positions, durations and use of verbal tenses in the narration are usually meant to give some landmark to the reader/listener. They are described in absolute or relative terms. Once interpreted, they create a relation between events/conditions *contingent to the story.* [7] The correspondent positioning constitutes the **medium constraints**.
4. When we do not have any other information, a possible sequence is suggested by the discourse-relative time, i.e. relative position in which the events are given. The consequent representational outcome is *contingent to the discourse* and provides the **weak constraints** on the ordering of events. They complement the ordering resulting from the medium constraints.

In the previous section, we presented the story as a strict ordered set of events. However, it is easy to object to such a strict determination: (a) dependencies can be associated to no-time-consuming processes (e.g. logical dependencies); (b) events may occur simultaneously, when triggered by parallel sub-systems (e.g. two agents acting independently), unless there is an explicit temporal determination. Consequently, we weaken the previous strict temporal constraints (from $e_{i+1} > e_i$ to $e_{i+1} \geq e_i$) at least in these two cases. With these modifications, the set of events $\mathcal{E}$ defined in (1) becomes a *partially ordered set.*

Evidently, most of the strong constraints proposed in step 2 are relative to the reader, as only some of these dependencies are explicitly presented by the narrator. They respectively define the background and foreground **mechanisms** of the story-system. Conversely, the medium and weak constraints are always explicitly addressed in the narrative and can be objectively extracted as intrinsic component of the **observation**. They describe *contingent* relations, which are also *contextual* when they are part of the **synchronization**: i.e. the necessary alignment with the mechanisms for the story to occur.[8] Suggested by the term control-flow in programming, we call the whole composition of constraints *story-flow.*

[6] Unfortunately, there are conflicting accounts about its definition in the literature. For some authors the plot coincide with how things are presented, and therefore it practically equals the discourse. According to an older tradition, usually associated to Forster [10], the *story* properly said is only the chronological sequence of events, while the plot is the causal and logical structure connecting them.

[7] Contingent to the story/discourse means that even if this specific story/discourse reports this ordering, *a priori*, there may be as well stories in which an alternative ordering holds.

[8] Considered as a whole, however, constraints may be conflicting. When this occurs, it is a symptom of a problem with the mechanisms and/or with the observation. There might be dependencies which are missing, not valid or not acceptable in that specific context, or there may be faults in the timing or the nature of the reported events. Not addressed in this paper, this problem is one of the objects of our current research on *model-based diagnosis* and *justification* [25].

▶ **Example 2.** Applying the method on the "brute" story[9] of *Pierson v Post*, we have:
- conditions and events: Post hunting (c_1), Post being in an uninhabited land (c_2), Post catching the fox (c_3), Pierson being conscious of Post's pursuit (c_4), Pierson intercepting the fox (e_1), Pierson killing the fox (e_2), Pierson taking the fox (e_3)
- strong constraints: $e_1 < e_2 < e_3$ (intercept, kill, take necessarily occur in this order)
- medium constraints: $\{c_1, c_2, c_3\} \xrightarrow{e_1} \{\}$, $\{c_4\} \xrightarrow{e_1} \{\}$
- weak constraints: $e_1 < e_2 < e_3$

Conditions like 'Post hunting' refer to ongoing actions which started in an undefined moment before the given story occurs. Note how the weak constraints reproduce the strong constraints: this is a natural tendency. In general, however, other events may occur in the story with no relevance for the causal mechanisms applied by the interpreter or with no specific ordering necessity.

Talking about mechanisms, the judges propose two institutional interpretations, which, added to the previous strong constraints, produce two alternative stories:
- $\{c_6\} \xrightarrow{e_3} \{c_7\}$: the fox being a wild animal (c_6), the event of Pierson taking the fox (e_3) makes Pierson owner of the animal (c_7);
- $\{c_1, c_2, c_4\} \to \{c_8\}$: Post hunting in an uninhabited land (c_1 and c_2), and Pierson conscious of his pursuit (c_4) gives Post an exclusive right to catch the prey (c_8), and, consequently, Pierson is not permitted to.

The last constraint involves only conditions, it is a logical dependency; it can be translated similarly to the others if we take into account some condition-activating event, for instance the last one (Pierson becoming aware of Post's hunting).

4 The agent-role model

So far, the foundational structure of the story model consists of events, generic continuant entities and relations between them. Amongst continuant entities, characters are particularly important in narratives, as they connect events all throughout the story with their direct or indirect participation in actions.

Similarly to Propp, who, investigating Russian folk-tales [20], abstracted characters to *roles* defined by recurrent patterns of actions (the Villain, the Hero, etc.), we abstract agents to **agent-roles** (first presented in [8]). Agent-roles are *roles*, as they refer to prototypical patterns of behaviour (correspondent or building on top of roles defined by institutions), and they are *agents*, because their behaviour is described via cognitive and motivational components. In previous works [25, 24], we presented a multi-layered framework to be used for the characterization of agent-roles, summarized in Table 1.

Integrating some fundamental mechanisms inspired by BDI architectures (*beliefs-desires-intentions*) we relate the primary elements of each layer with catalyzers and with components of other layers, in order to construct a more in-depth representation of the strong constraints. The layers essentially reproduce the general story scheme used by Bex and Verheij in [7], and synthetizing in turn what was proposed by Pennington and Hastie in [19]:

$$\textit{Motive} \to \textit{Goal} \to \textit{Action} \to \textit{Consequences}$$

[9] We are referring to Searle's theory on institutions [22], which distinguishes *brute*, raw facts—in the sense of belonging to the world of experience—from *institutional* facts, i.e. facts which are meaningful within an institutional framework. Only some of the brute facts *count as* institutional fact, depending on constitutive rules.

Table 1 Multi-layered framework to be used for the characterization of agent-roles.

	Primary elements	Catalyzer elements
Motivational layer	Motive	Motivation
Intentional layer	Intention	Affordance (perceived power)
Action layer	Action, Attempt	Disposition (actual power)
Signal layer	Message, Outcome	–

This scheme serves as a template to model the behaviour of each agent. In general, however, the complete decomposition is not fully expressed in a narrative, but retroactively occurs in the mind of the interpreter, helped by narrative clues and following his own conceptualization of the world.

In order to trace the relevant dependencies, we follow a methodology consisting in the elicitation of (a) *motives*: we identify the events which are reasons for action; (b) contextual *affordances*: we write down which conditions, in this story-world, are sufficient for an agent to consider to be successful in starting a course of actions aiming to a certain intent; in doing this, we reconstruct as well the course of actions as a hierarchical plan; (c) *dispositional rules*, modeling the agent-independent dependencies holding in the story-world. Obviously different modelers may provide alternative solutions. However, for our acquisition purposes, we take a neutral perspective toward the problem of deciding which are the "right" mechanisms representing the world: if the story-model, when executed, reproduces the messages given with the observation, it is *valid*.

▶ **Example 3.** Executing these elicitation tasks on our story, a possible result is:

- for both Pierson and Post the core action is catching/taking the fox. A possible initiating motive is having seen the fox (not explicitly given), while the motivation would be associated to their involvement in a hunting activity or their proneness to hunt;
- the affordance of the core action, in respect to this story-world, is hidden to the reader. We assume that both of them thinks that they are able to take the fox in those conditions. The specific sequence of actions to be executed can be easily reconstructed via a chain of dependencies: e.g. you can take the fox, if you kill it; you can kill it, if you intercept it;
- if someone has already caught the fox, nobody can physically take it any more.

Institutional characterization. *Institutional power* (in legal terms also called *ability*) and *permission* can be described similarly to affordance, as they are assumed to be taken into account by the agent when he decides whether to proceed on a certain behaviour. The former is necessary for the action to be recognized by the social system; the latter identifies the liability of the agent to some enforcement action in case of violation.[10] For the sake of brevity, we redirect the reader to [23] for further support on these claims.

Expectations, failures and successes. Relations as powers, obligations and permissions can be used to describe expectations about the social behaviour of the others in terms of normative possibility and necessity, just as affordances describe (expected) possibilities of action to agents in a certain environment, and dispositional rules describe the laws of a certain world. If the agent starts an action and is not successful in achieving his intent, then he acknowledges a *practical failure*. If the agent performs an act he considers institutionally

[10] On the other side, *obligations* not yet fulfilled are prototypical motives for action for the addressee of the obligation. As permissions, they are generally associated to some form of enforcement.

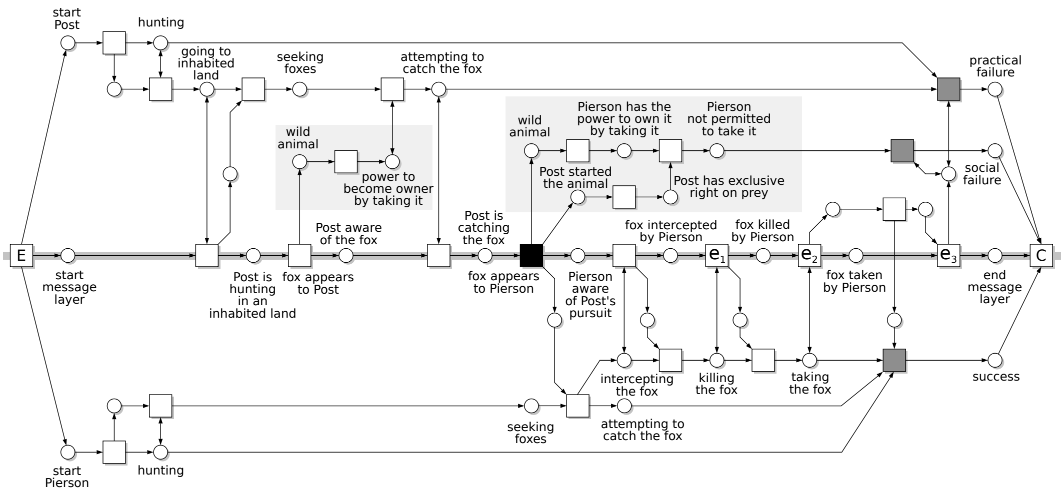

Figure 1 Simplified Petri Net representation of *Pierson v Post*.

meaningful, but this is eventually not recognized as such, he has still failed in respect to his intents. If the agent intentionally performs an act which is not permitted or does not satisfy a given duty, there is an *institutional failure*, but if the intended outcome is still successfully established, then it will still be a *practical success* for him, even if enforcement actions may reduce the general pay-off. The interactions between intents, practical/social expectations and actual outcome entail the failures or successes for the agents, also in social terms.

5 Translating the story-flow as a Petri Net

Within the formalisms used in computation, Petri nets[11] are one of the best established tools for *process modeling* and *analysis*. They mirror the definition of story model we constructed above, because they allow to explicitly divide conditions (represented with places) from events (with transitions), and reproduce changes of state via the movement of tokens, respecting the partial ordering property we associated to the story-model.

We have reported in Fig. 1 a simplified representation of our case story, obtained from the composition of its constraints, in order to informally explain the construction principles of our proposal. Three macro-areas can be recognized. The first, the *message layer*, corresponds to the central line, and contains the events/conditions provided by the observation. The arcs on this line chronologically reproduce the *synchronization* between external and internal events. Agents or other parallel subsystems (in our case, Pierson and Post) start together with the message layer and interact through it.[12] Their subnets contain elements belonging to all other three layers described in 4.

[11] A Petri net is a directed, bipartite graph with two types of nodes: *places* (visualized as circles) and *transitions* (bars). A place is connected only to transitions and vice-versa. One or more *tokens* (black dots) can reside in each place, while transitions can be *fired*, moving those tokens from their input places to their output places. Petri nets furnish a direct visual representation of the causal structure (via the network) and of the behaviour (via the movement of tokens) of the system.

[12] The picture shows some fundamental patterns. For example, a simple "writing" pattern is attached to "going to inhabited land" place; a simple "reading" pattern connects the transition "fox appears to Pearson" with the transition after "seeking foxes"; a complete communication pattern, which separates emission from reception, surrounds the "fox taken by Pierson" place. See [25] for other examples.

The core action starts when the fox appears to Pierson (black box). Pierson acknowledges it, as he is seeking for foxes (and therefore is prone/motivated to see them), and commits himself to the catch, executing a specific sequence of actions. On the other side, Post was already trying to catch the fox. We modeled Post's institutional thinking (highlighted with the grey boxes), assumed to be similar to Livingston's interpretation. Post started the action as Pierson, but the Petri net shows also that he infers the institutional power to take it, before he attempts to (left box). The same mechanism is hereafter applied to Pierson's intervention (right box), but is *defeated* by a second mechanism which gives Post the exclusive right on the prey. From Post's perspective, the event of taking the fox is therefore not only a practical failure, but also a social failure.

6 Discussion

The paper introduces several elements towards an alternative framework for narratives:

- by integrating intentions and institutional concepts we are able to increase the deepness of the representation in order to model motivational and social aspects of stories, relevant to describe legal cases, but usually not explicitly targeted in other formal accounts;
- the use of Petri nets as underlying computational model makes the story-model execution a direct possibility, useful as well for real-time visual debugging and validating purposes. Other contributions referring to Petri net have been proposed for *story plot generation* in games [5] and for *narrative comprehension* [18, 12]. Although they have similarities with our approach (in particular the latter), the first describes only higher-level specifications, the second focuses with much further detail on narrative discourse components, while we focus on the acquisition of the "systematic" structural core of an interpreted story;
- *causations* and *expectations* are integrated in the same framework, overcoming mutual limitations of other frameworks (cf. [16]); furthermore, the connection with concepts as affordances, power, permission/obligation is, as far as we know, a novelty in the domain;
- the difference between expectation and actual outcome — which eventually defines *failure* or *success* for a character — is evaluated within the model itself. Therefore, the narrative analyst is not concerned anymore by this meta-interpretation, as occurs instead in *plot units* [13] or in *story intention graphs* (the "affectual" components) [9];
- rather than static *script*-like knowledge to be used in story-understanding, we focus on acquiring from modelers different interpretations of the fabula; assessing a case with alternative interpretations is just a daily practice in legal activity, and our representational framework aims to collect the correspondent mechanisms.

Obviously, the increase of knowledge requirements corresponds to increased effort in the modeling exercise. Ideally, this should not be a problem with end-users as law students and experts working on a legal scenario, because the visualization of the mechanisms produces also the direct effect of clarifying and validating the ideas of the modeler. In this direction, the choice of relying on visual programming practices aims to help the interaction with non-IT experts.

Moreover, we think there are two other reasons why the impact may be less critical than it seems. On the one hand, the elicitation of mechanisms is mostly targeting the *affordances* and *dispositions* related to actions/events, which are *the* fundamental components of practical rationality. We assume nobody should have particular problems with this part, if supported with an adequate acquisition platform. The composition of constraints, which is a more delicate and complex task, can be instead supported computationally (problems known in AI as *configuration* and *model-based diagnosis*). On the other hand, once a story is collected, its mechanisms can be reused with another story. Evidently, in some cases part of those mechanisms would not directly apply; in such situation, the modeler will be obliged to define distinguishing features. This incremental, constructive approach reflects essentially the nature of *case law*. However, the overall impact of these potentially positive interactions with the knowledge acquisition bottleneck issue remains to be investigated in the future.

Some final remarks about a related domain. Traditionally, *legal case-based reasoning* binds the modeling of cases to *dimensions* (HYPO [3]) and *factors* (CATO [2]), i.e. concepts which translate legally significant aspects of the cases. The story behind the case and its construction is therefore neglected, apart from relevant components extracted by the analyst. The analyst is then the one responsible for finding the analogies and for placing the case in the right abstraction. Potentially, our framework could automatize part of this process, if the case-base is adequately rich and we implement an adequate measure of similarity.

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Multilevel Accentuation and its Role in the Memorization of Narrative*

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Abstract

The paper is dedicated to the phenomenon of accentuation on multiple narrative levels. Accentuation is a textual device that indicates the elements of narrative that have to be memorized by readers. It is different from the well known notion of foregrounding, as accentuation does not violate the norm, but, on the contrary, is in itself conventional. While foregrounding draws readers' attention involuntarily, the accentuation is a way of facilitating the work of voluntary attention. In this latter case a text as if takes on itself a part of the unpleasant burden of purposeful concentrating of attention, so that the reading process becomes more comfortable. The paper describes the general principles of accentuation and also presents a typology of accentuation devices, based on a six-level model of narrative. It encompasses five main types (three syntactic ones and two semantic ones), including numerous subcategories.

1998 ACM Subject Classification J.4 Social and Behavioral Sciences, J.5 Arts and Humanities

Keywords and phrases accentuation, attention, memory, level model of narrative

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1 Introduction

The aim of the present work is to describe a specific system of indicators that I call *textual accentuations*. The notion to be described is quite similar to the notion of accentuation (or stress) in linguistics, where it is defined as "the degree of force used in producing a syllable" [3, p. 454]. One of the types of accentuation, the closest one to textual accentuation, is sentence stress, in case of which a word or word combination is made to stand out in a sentence by means of the increase in loudness, length or pitch. This type of stress already contains several important components that will be included in the definition of textual accentuation. First, in the case of sentence stress one of the units of a message is made different from the rest of units. Second, this different position has a conventional meaning of importance. Third, the choice of which word should be stressed is made by the speaker, not by someone else (i.e. the distinction between important and unimportant words of a sentence is already a structural feature of the sentence). Fourth, there may be nothing atypical about the word under stress, so that it is not extraordinary in itself, but is made extraordinary by means of accentuation.

One of the main claims of this article is that accentuation can be performed not only by phonological devices, but also by numerous other means. Many of them can be noticed only if we shift from the narrow perspective of sentence to the broader perspective of the text as

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whole. Some of these textual accentuations are well-known, such as italics or underlining, but, at the same time, there are lots of other types of accentuation,[1] which are much more widespread, though being much less noticeable. In what follows I will make an attempt to demonstrate the variety of these devices and their important role in text comprehension. In particular, I will claim that accentuation has the important function of attracting readers' attention to certain textual elements, and therefore influencing their memorization of the text.

From the beginning a principal distinction should be made: accentuation is different from another type of attracting readers' attention, typically called *foregrounding* (or *defamiliarization* [25, 39]). Certain elements of a text may be called foregrounded if they capture attention by being unusual. Leech defines foregrounding as "motivated deviation from linguistic, or other socially accepted norms" [20, p. 30]. Researchers from the field of "empirical literary studies" have showed that atypical, foregrounded text elements are more memorable than the ordinary, not defamiliarized ones [38]. Despite the fact that both foregrounding and accentuation capture attention, there are important reasons to distinguish between these two notions. We pay attention to the foregrounded elements automatically, as they are interesting, atypical, extraordinary. The human brain is wired to pay attention to unusual things and to memorize them, and this psychological feature is effectively exploited by foregrounding devices. Accentuation, on the contrary, captures readers' attention by convention. For example, there is nothing particularly interesting about the fact that a word is italicized. Italics are not an unusual thing, and the reason why they may capture someone's attention is completely different. There exists a linguistic convention that if a word is italicized (or underlined, colored, etc.) it is considered important by the author of the text, and therefore it would be reasonable to pay attention to this word and to memorize it.[2] Being explicated, the meaning of accentuation roughly corresponds to the phrase: "Pay attention to this text unit!" In the case of accentuation attention is produced by our purposeful effort (though, purposeful does not necessarily mean conscious).[3]

The opposition between foregrounding and accentuation is an example of a more general opposition between involuntary and voluntary attention (and remembering), well described in the classical works of Soviet psychologists such as Lev Vygotsky [40] and Alexander Luria [23]. Luria defines this opposition in the following way:

1. *involuntary* attention takes place "when the attention of a person is attracted directly by certain either strong, either new or interesting (according to the need) stimulus" [23, p. 25];
2. *voluntary* attention is typical only for humans. It happens when "a person voluntarily can concentrate his or her attention on one or another object, even if there is nothing changing in his surroundings" [23, p. 26].

As it seems, such poetic devices as metaphor or intrigue capture our attention involuntarily.

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[1] For the sake of simplicity in what follows I will use the terms "textual accentuation" and simply "accentuation" interchangeably.

[2] However, sometimes it may not be reasonable to completely rely on the narrator's use of accentuation and foregrounding. Improper accentuation seems to be a common technique in so-called "unreliable narration," often encountered, for instance, in detective fiction [9].

[3] At the same time, there exists the possibility that defamiliarization may be used as a tool for facilitating accentuation. For instance, informing readers about an interesting (i.e. foregrounded) detail of a character's appearance may convey an implicit message of this character's importance for further plot development. This interplay between foregrounding and accentuation seems to be a rather complicated and broad topic itself and thus will not be addressed in the present article.

For example, in the case of intrigue, you want (that is, you feel desire) to know the rest of information, which is given only partially. Here we face the functioning of a relatively simple neurobiological mechanism. On the contrary, in the case of voluntary attention you may not feel any pleasure triggered by the objects that capture your attention. In this case, it is a kind of work to concentrate on something. This work may be not very pleasant, but it is expected that the benefits of concentrating attention and memorizing will overbalance the amount of unpleasant effort. Accentuation may be regarded as a technique of facilitating the work of voluntary memorizing. In the case of accentuation the difficult task of deciding what is important to pay attention to becomes partially conveyed by the text itself. Accentuations are indices that inform readers about those characters, locations, phrases and other textual elements they should pay attention to first of all. These indices simplify memorization and make the comprehension process simpler: readers lose less information, and therefore are better prepared to receive further information provided by the text.

I believe that various accentuation devices are very widespread and can be found in almost any type of text. However, the present article does not contain any evidence to support this belief. Its aim is more modest – to analyze the functioning of accentuation in just one type of text, that of literary narrative. Literary narrative seems to be very rich in accentuation devices, and, thus, it is a convenient material for the assigned task.

2 Basic principles of accentuation

As I will show further, accentuation mechanisms are tightly connected to the levels they function at. That is why a clear and well structured model of narrative levels is the necessary basis upon which a coherent model of accentuation types can be constructed. The model of levels that will be used in the present research is a new one, though being partially based on already existing multi-level models developed in the field of discourse psychology [16, 36, 37] and, to a lesser extent, on the models introduced by literary narratologists.

The model to be used consists of three main levels:

1. the level of *surface structure*;
2. the level of *narrative structure*;
3. the level of *thematic structure.*

Surface structure corresponds to the medium by means of which a narrative is represented: natural language, film, comic strip, etc. The minimal elements of surface structure are the same as the minimal elements of the medium. For example, in the case of natural language these are words. Narrative structure corresponds to the common understanding of narrative with events and facts as its minimal elements. Thematic structure is equivalent to macrostructure, the notion coined by van Dijk [35, 36], i.e. a specific "shortened" version of text, its semantic core which conveys the main meaning of a story.[4] The basic units of thematic structure are thematic events and thematic facts. They should be considered separately from the regular events and facts of narrative structure because of the difference in importance – thematic units have a more important structural and mnemonic role than narrative ones. Thematic elements form the gist of the story, which can be retained in

[4] I use the term "thematic structure" instead of "macrostructure" for two reasons. First, the latter notion logically requires the use of its counterpart – "microstructure," however the introduction of one more term would make the proposed model even more complicated. Second, the term "theme" is widely used in discourse psychology to indicate a concept very similar to macrostructure, while at the same time being more intuitively understandable.

memory for a long time, much longer than the elements of narrative structure (for a more detailed explanation of thematic units see subsection 2.4).

Each of these three main levels is divided into two sublevels: *semantic* and *syntactic*. Every semantic sublevel encompasses the sum of units of a certain level, and every syntactic sublevel encompasses the sum of syntactic relations between them. For example, the semantic sublevel of surface structure conveys information about the semantic units of this level, i.e. about words and word combinations, while the syntactic sublevel of the same level represents the syntactic relations between them in a sentence, as well as their "graphic" specificities, such as being italicized or underlined. At the level of narrative structure, the distinction between semantic and syntactic sublevels roughly corresponds to the distinction between story and plot. The latter encompasses the principles of distortion (narrative frequency, anachronies, etc.) of the simple chronological organization of the former. The syntactic sublevel of thematic structure includes some very general principles of the organization of thematic units, such as the well-known notion of narrative schema that may include such elements as "setting," "change of state," "ending," etc. [8, 28, 34].

The main principles of accentuation are shown in Figure 1. The arrows indicate which levels of a story can be linked together by the relation of accentuation. According to the direction of the arrows, some elements of the higher levels can function as *accentuators* of some elements of the lower levels (*accentuated* elements). It should be stressed that these are not levels accentuating other levels, but units of these levels accentuating each other. Moreover, not all the elements of a certain level can be used for accentuation, only specific kinds of them can perform this function. Taking this into account, the first principle of accentuation can be formulated in the following way:

1. Elements of higher text levels can be used to accentuate the elements of lower levels.

What does it mean for a text element to be an accentuator? Each accentuating unit conveys a specific message with respect to an accentuated element of a lower level. Accentuators transfer a message about the *importance* of an accentuated element. Simply stated, it tells the reader: "Pay attention to element x!" The system of accentuation can be compared to the system of red flags indicating some principal locations on a topographic map.

Obviously, the elements of the lowest level of the model cannot function as accentuators because there is nothing to accentuate below. Similarly, the highest level cannot be accentuated. At the same time, there are some other reasons why the highest level, i.e. the syntactic sublevel of surface structure, can only function as an accentuator and cannot be accentuated. Here we come to the second important principle of accentuation:

2. Elements of syntactic sublevels typically cannot be accentuated. Only the elements of semantic sublevels can perform the roles of both accentuated and accentuator.

Of course, this does not mean that the latter claim applies to the same elements of semantic sublevels. I am not stating that, for example, one and the same word is both accentuated and accentuator. Rather, words can play both the roles of accentuator and accentuated, while syntactic structures, e.g., focalization, usually can be used for accentuating some narrative facts, but they cannot be accentuated.

An important specification should be made here. The second principle of accentuation does not mean that syntactic sublevels cannot be accentuated at all. It rather means that such accentuations are extremely rare (and that is the reason why they will not be taken into account in this study). In fact, in literary narratives there are no specific mechanisms of

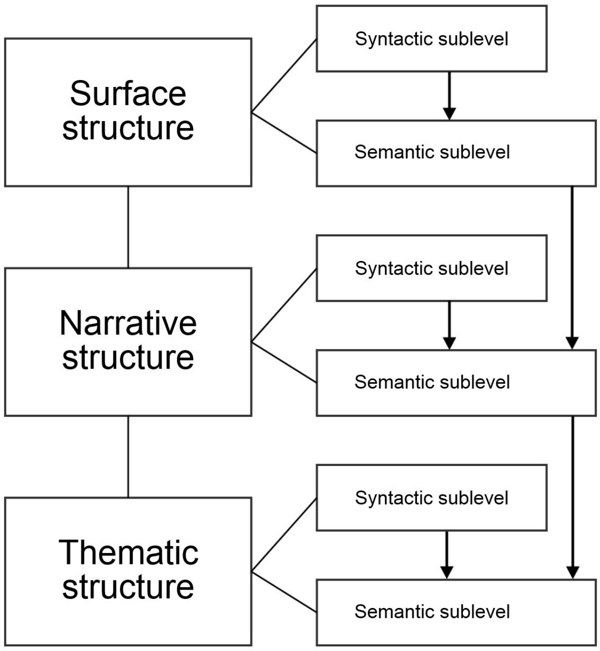

Figure 1 Levels of accentuation in a narrative.

stressing syntactic sublevels, except for the most flexible sublevel of text, that of semantic sublevel of surface structure, which can be used as a means of such accentuation. Of course, with the words of natural language we may accentuate almost everything, and sometimes authors do employ such stress. For example, a narrator in principle may stress some syntactic units, such as focalization, by saying: "Pay attention to the focalization used." This type of stress on syntactic constructions was described by the Russian formalists under the term "laying bare of the device" (obnazhenie prijoma) [12, p. 63]. For example, Shklovsky showed how Laurence Sterne extensively laid bare some plot constructions in his novels [32].

Having established the main principles of accentuation, I will proceed to develop the typology of accentuation forms. This taxonomy will be based on the level model of text described above. Each type of accentuation will correspond to one of the arrows in Figure 1.

3 Types of accentuation

3.1 Syntactic sublevel of surface structure → Semantic sublevel of surface structure

At present, the most thoroughly studied type of accentuation is that in which some elements of the syntactic sublevel of the surface structure are used to stress certain words, i.e., semantic units of the same level. In particular, important experimental studies of this kind of accentuation were conducted by the research group headed by Catherine Emmott and Anthony J. Sanford [10, 11, 29, 30]. These scholars have found solid empirical arguments to confirm the intuitively understandable fact that such devices as italics or cleft structure do capture readers' attention. Thus, there is no reason to discuss these narrative devices extensively. However, I should mention that the most convenient and, perhaps, most ontologically grounded approach to the typology of syntactic accentuations would be to divide them into two categories: graphical and grammatical devices.

A. Graphical devices

- *Italics*
- *Coloured type*
- *Capital letters*, etc.

B. Grammatical devices

- *Clefting*

E.g.: It was Leo Tolstoy who loved children very much.

Such cleft structure makes readers pay much more attention to the name Leo Tolstoy than the usual construction: Leo Tolstoy loved children very much.

- *Indefinite "this"*

As Givon explains it, "there is a strong statistical association in spoken American English between the use of the indefinite 'this' and the topic-persistence (TP measure) of the referent" [15]. That is, usually to stress the importance of a word indefinite "this" will be used instead of indefinite "a." If there are two sentences: "Then he approached a house." and "Then he approached this house," the word "house" will be better recalled in the second case.

3.2 Semantic sublevel of surface structure → Semantic sublevel of narrative structure

Words can accentuate the importance of certain events and facts of the storyworld. I assume that some words convey not only their usual meaning, but also an additional meaning of importance. This second meaning (that of accentuation) can be more or less explicit. It may be given directly: "This character is important." Or it may be put in a more implicit way: "This character is an extraordinary personality," which attracts our attention because we know that unique, exceptional characters often have important plot roles. Some types of accentuation by means of the semantic sublevel of surface structure are even more implicit. What follows is a short categorization of this type of accentuation.

A. Direct indication of the importance of a fact

> In the accompanying diagram this arrangement of the ground floor can be easily visualized, and *I suggest that the reader fix it in his mind*; for I doubt if ever before so simple and obvious an architectural design played such an *important part* in a criminal mystery. [6, p. 24, my emphasis]

- *indication that a fact is strange*

> About two o'clock the mist cleared away, and we beheld, stretched out in every direction, vast and irregular plains of ice, which seemed to have no end. Some of my comrades groaned, and my own mind began to grow watchful with anxious thoughts, when a *strange sight* suddenly attracted our attention, and diverted our solicitude from our own situation. We perceived a low carriage, fixed on a sledge and drawn by dogs, pass on towards the north, at the distance of half a mile: a being which had the shape of a man, but apparently of gigantic stature, sat in the sledge, and guided the dogs. [31, my emphasis]

- *indication that a fact is unique*

> *I never saw* a more interesting creature: his eyes have generally an expression of wildness, and even madness; but there are moments when, if any one performs an act of kindness towards him, or does him any the most trifling service, his whole countenance is lighted up, as it were, with a beam of benevolence and sweetness that *I never saw* equalled. But he is generally melancholy and despairing; and sometimes he gnashes his teeth, as if impatient of the weight of woes that oppresses him. [31, my emphasis]

- *indication that a fact is unbelievable/fantastic*

> You will hear of powers and occurrences, such as you have been accustomed to believe *impossible*: but I do not doubt that my tale conveys in its series internal evidence of the truth of the events of which it is composed. [31, my emphasis]

C. Indication of the interestingness of a fact

> If I should be engaged, I will at least make notes. *This manuscript will doubtless afford you the greatest pleasure*: but to me, who know him, and who hear it from his own lips, with what *interest and sympathy* shall I read it in some future day! [31, my emphasis]

D. Indication of the suddenness of a fact (i.e. unexpectedness, which, in a certain sense, is a synonym of interestingness)

> As I said this I *suddenly* beheld the figure of a man, at some distance, advancing towards me with superhuman speed. He bounded over the crevices in the ice, among which I had walked with caution; his stature, also, as he approached, seemed to exceed that of man. I was troubled; a mist came over my eyes, and I felt a faintness seize me, but I was quickly restored by the cold gale of the mountains. [31, my emphasis]

Interestingly, this excerpt is a good illustration of the fact that accentuations of different types are often put together to make the emphasis stronger. In this short text the indication of the suddenness is accompanied by accentuation via utmost qualities ("superhuman speed," "his stature [...] exceed that of man").

E. Usage of the words indicating utmost qualities

> We were at the bottom of one of these abysses, when a quick scream from my companion broke fearfully upon the night. "See! see!" cried he, shrieking in my ears, "Almighty God! see! see!" As he spoke, I became aware of a dull, sullen glare of red light which streamed down the sides of the vast chasm where we lay, and threw a fitful brilliancy upon our deck. Casting my eyes upwards, I beheld *a spectacle which froze the current of my blood.* At *a terrific height* directly above us, and upon the very verge of the precipitous descent, hovered *a gigantic ship of, perhaps, four thousand tons.* Although upreared upon the summit of a wave more than a hundred times her own altitude, *her apparent size exceeded that of any ship of the line or East Indiaman in existence.* [26, my emphasis]

This example demonstrates not only the use of a specific type of accentuation, but also the fact that similar types of accentuation can be situated in a text closely to each other. In this case the use of words indicating the utmost qualities is not singular but repeats several times. Similarly, a quite direct indication of importance is used ("'See! see!' cried he, shrieking in my ears, 'Almighty God! see! see!").

F. Usage of proper names. The research of Garrod and Sanford [13] showed that in cases where a character is introduced with a proper name, the chances that readers will create a retrieval cue for this character in their memory are much higher than in cases where the characters are introduced with a common name. Thus, it is logical to assume that the usage of proper names performs the function of accentuation conveying the message: "This character is important!" The logic is very simple here: the remembering of a proper name demands some extra efforts (because proper names are the extreme case of conventional signs, usually having nothing in common with the designated person[5]), and therefore readers assume that such additional work is proposed to be done not in vain. The memorization of the proper name of a character should somehow simplify further reading. So, it is expected by readers that the mention of a proper name means that the character will remain active in further parts of the narrative text. It would be quite interesting to compare the role of proper names in two excerpts taken from different literary narratives – Shelley's *Frankenstein* and R. L. Stevenson's *Treasure Island*. The following situations are very similar: a protagonist wants to choose a crew for his ship and in both excerpts one of the candidates for entering the crew is described. However, in the first case this sailor is not an important character, as he will not participate in further plot development. The second case is very different – this sailor will become one of the principal actors in the storyworld.

> (1) I shall certainly find no friend on the wide ocean, nor even here in Archangel, among merchants and seamen. Yet some feelings, unallied to the dross of human nature, beat even in these rugged bosoms. *My lieutenant*, for instance, is a man of wonderful courage and enterprise; he is madly desirous of glory. He is an Englishman, and in the midst of national and professional prejudices, unsoftened by cultivation, retains some of the noblest endowments of humanity. I first became acquainted with him on board a whale vessel: finding that he was unemployed in this city, I easily engaged him to assist in my enterprise. [31, my emphasis]

> (2) I wished a round score of men – in case of natives, buccaneers, or the odious French – and I had the worry of the deuce itself to find so much as half a dozen, till the most remarkable stroke of fortune brought me the very man that I required.
> I was standing on the dock, when, by the merest accident, I fell in talk with him. [...]
> He had hobbled down there that morning, he said, to get a smell of the salt.
> I was monstrously touched – so would you have been – and, out of pure pity, I engaged him on the spot to be ship's cook. *Long John Silver, he is called*, and has lost a leg; but that I regarded as a recommendation, since he lost it in his country's service,

[5] However, there exists a category of "meaningful names" in literature, the signifiers of which are not fully conventional, indicating some traits of the character's personality. For example, in the novel *Flowers for Algernon* by Daniel Keyes [19], the sister of a mentally retarded main character is called Norma. Personal names like this, having clear semantics, not only help to better characterize an actor in a storyworld, but also facilitate the reader's task of remembering these names, which may be quite useful in cases of long novels loaded with characters.

under the immortal Hawke. He has no pension, Livesey. Imagine the abominable age we live in! [33, my emphasis]

What is interesting about these two examples is not only the important role of proper names, but, in fact, the crucial role of proper names in the reader's decision about whether to memorize a character or not. Both characters – the nameless lieutenant and John Silver – are introduced not just by a common word or a proper name, but their introductions are supplemented with short descriptions. However, in the first case this description is a secondary element, not an important unit of the plot (at least, from the cognitive perspective, i.e. this description of the nameless lieutenant may be forgotten without any detriment to the further comprehension of the text). But in the second case the description of John Silver is not simply an interesting detail. It contains some facts that will remain important and, moreover, will essentially alter their meaning. For instance, the evaluation of the fact that Silver has lost his leg will be crucially different when readers get to know that he is a pirate, which makes his injury a typical trait of the image of a sea bandit. Thus, neither in the first nor second example does the presence of a short description help readers finally decide if the character described is important or not. And it seems logical that, in fact, such decisive role is performed by the presence or absence of a proper name. The given list is by no means complete – the types of accentuation via the semantic sublevel of the surface structure are much more diverse, and a more or less exhaustive description of them would demand a separate study. Moreover, it would be rewarding to study how these devices have changed throughout the history of narrative literature. Perhaps some regularities might be found. Also, there may be significant differences between the types of accentuation at this level in different cultural traditions. The aim of the given overview has been only to provide a general impression of how diverse this means of accentuation may be.

3.3 Syntactic sublevel of narrative structure → Semantic sublevel of narrative structure

This subsection will analyze those syntactical (or plot) devices that may be used to accentuate some elements of the storyworld. Of course, plot devices are numerous, and only some of them can be used to stress the importance of certain events and facts. It could be that the majority of plot devices are neutral from the perspective of accentuation. For example, it is unlikely that focalization can be used as an accentuator. At the same time, there are certain cases when formal aspects of storytelling may accentuate certain facts of the storyworld. Below I will examine three of these, which are widely used in narrative literature.

A. Repetition. It is logical to assume that if a fact is repeated several times it must be regarded as important, and therefore should be memorized. However, at first I will explain what type of repetition is meant, as there are several of them. For example, Jean Cohen has distinguished between three types of repetition in literature: repetition of the sign, of the signifier, and of the signified. In the first case there is a complete repetition of a word or some larger part of the text. The second case encompasses such poetic devices as alliteration, assonance, rhyme or meter. The third case includes synonymy and pleonasm [27, p. 152]. I will consider predominately repetition of the third kind, i.e., repetition of the signified. These signified elements will be events and facts in a certain storyworld, which can be repeated by means of different word combinations. However, in some cases an event can be repeated via one and the same word combination, though such occurrences seem to be rare.

To illustrate how extensively this accentuation device may be used in narrative literature, I will analyze several paragraphs from the beginning of *A Christmas Carol* by Charles Dickens. The first two paragraphs of the text contain several repetitions of the fact that Marley, one of the principal characters of the story, is dead (I have italicized several quite similar ways in which this fact is mentioned):

> *Marley was dead*: to begin with. There is no doubt whatever about that. The register of his burial was signed by the clergyman, the clerk, the undertaker, and the chief mourner. Scrooge signed it. And Scrooge's name was good upon 'Change, for anything he chose to put his hand to. *Old Marley was as dead as a door-nail.*
> Mind! I don't mean to say that I know, of my own knowledge, what there is particularly dead about a door-nail. I might have been inclined, myself, to regard a coffin-nail as the deadest piece of ironmongery in the trade. But the wisdom of our ancestors is in the simile; and my unhallowed hands shall not disturb it, or the Country's done for. You will therefore permit me to repeat, emphatically, that *Marley was as dead as a door-nail.* [5, my emphasis]

In these two paragraphs there are at least three mentions of the fact that some character called Marley died. These repetitions, I assume, stress the importance of the character, or at least the importance of the fact of his death. Marley's death will be also mentioned in several neighboring paragraphs, though with less persistence. Incidentally, the importance of Marley is also stressed by him being introduced with a proper name, which is one more type of accentuation described above. The reason for such strong accentuation is quite obvious. The death of Marley is one of the keystones of the plot, and further on readers will see that Marley is not fully dead. He will become a ghost, and to have the possibility of noting how amazing this fact is, readers should first memorize the fact that Marley is not alive.

The main characteristics of the protagonist of the story, Scrooge, are also stressed with intensive repetition:

> Oh! But *he was a tight-fisted hand at the grindstone, Scrooge! a squeezing, wrenching, grasping, scraping, clutching, covetous old sinner!* Hard and sharp as flint, from which no steel had ever struck out generous fire; secret, and self-contained, and solitary as an oyster. *The cold within him* froze his old features, nipped his pointed nose, shrivelled his cheek, stiffened his gait; made his eyes red, his thin lips blue; and spoke out shrewdly in his grating voice. *A frosty rime* was on his head, and on his eyebrows, and his wiry chin. He carried his own low temperature always about with him; *he iced his office* in the dog-days; and didn't thaw it one degree at Christmas. [5, my emphasis]

I have italicized only several expressions, which are the most obvious cases of repetition, but the whole paragraph might have been italicized, being one large accentuation by means of this device. It may be interesting to follow the structure of the repetitions in this paragraph. It begins with the explicit statement of the main trait of Scrooge, i.e. that he was tight-fisted. Then several quite concrete synonyms are given ("squeezing, wrenching, grasping, scraping, clutching, covetous"). The paragraph ends with a metaphorical representation of the same idea ("he iced his office in the dog-days"). Thus, the most concrete representation of the fact goes first and the least concrete one is situated at the very end. The aim of such structure, apparently, is to facilitate comprehension of the paragraph.

As well as in the case of Marley's death, the given paragraph is not the only one accentuating the negative personal qualities of Scrooge. They will be strongly stressed in the following several paragraphs, and a bit less intensively – throughout almost the whole story. The reason for such strong stress is quite obvious. The transformation of Scrooge from a terrible misanthrope into a nice person is a main causal axis of the narrative. This transformation is present on the thematic level of the text. That is the reason why it is accentuated so intensively, and not simply by means of repetition, but via other devices as well. One of them will be described in the following subsection.

B. Moral of a micro-story. Repetition is quite an explicit type of accentuation. One of the more implicit types is stress by means of a micro-story embedded in the larger body of narrative. These micro-stories should not be confused with the well-known notion of the text within a text [21] or a framed narrative. A micro-story in the sense used here is not a narrative situated on another diegetic level [2]. It is a story which functions as a parable, i.e. having a visible primary meaning, a moral, which could have been told in a more explicit way as well. A micro-story functions as an accentuation of this moral. See an example from *A Christmas Carol*:

> The door of Scrooge's counting-house was open that he might keep his eye upon his clerk, who in a dismal little cell beyond, a sort of tank, was copying letters. Scrooge had a very small fire, but the clerk's fire was so very much smaller that it looked like one coal. But he couldn't replenish it, for Scrooge kept the coal-box in his own room; and so surely as the clerk came in with the shovel, the master predicted that it would be necessary for them to part. Wherefore the clerk put on his white comforter, and tried to warm himself at the candle; in which effort, not being a man of a strong imagination, he failed. [5]

This micro-story should be regarded as one more way to say: "But he was a tight-fisted hand at the grindstone, Scrooge!" However, here this message is implicit, and readers have to make the inference about the miserliness of Scrooge for themselves. In the given example the task of making the inference from the micro-story is unusually easy, because this story appears right after several paragraphs asserting the miserliness of Scrooge in a more explicit way.

C. Change of narrative movement. Genette introduced a distinction between four types of narrative movements, each of which is defined by the correlation between story time and plot time[6]: pause, scene, summary and ellipsis [14, p. 95]. In the case of pause the story time "stops" and the plot describes the static storyworld. In the case of scene the plot time is equal to the time of the story (e.g., it happens in the dialogues). In the case of summary the plot time is shorter than the time of the story; an extreme example would be a short passage that tells the whole life story of a character. In the case of ellipsis some parts of the story are omitted, and thus the time of plot becomes equal to zero, while the time of the story may by indefinitely long. Usually in narratives these four movements are combined, changing each other, however we can also find some texts fully told via one of these movements (with the exception of ellipsis, of course).

[6] In the English translation of Genette's *Narrative Discourse* [14] the terms "story time" and "narrative time" are used. However, in the present article the latter term is substituted by its synonym "plot time" for the sake of terminological uniformity throughout the article.

Two of these changes in narrative tempo – pause and scene – can be used as means of accentuation. In these cases narration becomes more detailed, signifying that the narrated facts may be important and therefore should be memorized. However, accentuation by means of pause or scene cannot happen if the whole text is written in this tempo. In such case pause or scene would be neutral, not conveying any additional meaning. What makes them meaningful is the shift of narrative tempo, that is the situation when, for instance, summary is changed into scene, or when scene is changed into pause.

This accentuation via change from a faster narrative tempo to a slower one can be illustrated by the following example from *Frankenstein*. This excerpt tells how Frankenstein, who has just run away from his apartment (being afraid of his own monstrous creature), now attempts to return. This episode contains a shift in narrative tempo – from summary to scene – indicating the importance of Frankenstein's fear. The creator's fear of his own creation is one of the important facts of the storyworld, accentuated in the novel by other means as well. The sentences told via scene tempo are italicized:

> I trembled excessively; I could not endure to think of, and far less to allude to, the occurrences of the preceding night. I walked with a quick pace, and we soon arrived at my college. I then reflected, and the thought made me shiver, that the creature whom I had left in my apartment might still be there, alive and walking about. I dreaded to behold this monster, but I feared still more that Henry should see him. Entreating him, therefore, to remain a few minutes at the bottom of the stairs, I darted up towards my own room. *My hand was already on the lock of the door before I recollected myself. I then paused, and a cold shivering came over me. I threw the door forcibly open, as children are accustomed to do when they expect a spectre to stand in waiting for them on the other side; but nothing appeared. I stepped fearfully in: the apartment was empty, and my bedroom was also freed from its hideous guest.* I could hardly believe that so great a good fortune could have befallen me, but when I became assured that my enemy had indeed fled, I clapped my hands for joy and ran down to Clerval. [31, my emphasis]

3.4 Semantic sublevel of narrative structure → Semantic sublevel of thematic structure

This section will describe the situation in which some elements of a storyworld, i.e. certain events and facts, can be used to accentuate some elements of the thematic structure, i.e. certain thematic events and facts. However, this type of accentuation is less apparent and therefore some general theoretical premises of it should first be explicated.

The first thing to be done is to make a clear distinction between facts and thematic facts. This distinction is similar to the distinction between words (elements of the semantic sublevel of surface structure) and facts (elements of the semantic sublevel of narrative structure). At first sight, it may appear that there is no difference between the sentence "Leo Tolstoy loved children very much" and the fact of Leo Tolstoy loving children. However, such a difference does exist, because the sentence contains more information than the fact: not just information about the fact of the (story)world, but also about its linguistic representation, i.e. about the words chosen to transmit the message and their syntactic organization. The same logic applies to the distinction between facts and thematic facts. Thematic facts contain much less specific information, i.e. only certain very general ideas about characters, their relationships, the nature of the conflict, etc. In some sense, this may be called the most important information of the text.

As well as words, certain facts can convey the message "Pay attention! This is important!" However, in the case of events this semantics is fuzzier. The accentuating potential of the facts in a storyworld is similar to the importance of certain events in the real world. For example, it seems reasonable to expect that in ordinary everyday conversation, information about a plane crash and the subsequent adventures of the survivors in Amazonia will attract more attention than information about a safe trip home. Of course, the semantics of everyday facts depend on their context, and therefore it would be thoughtless to assume the existence of some general rule which would help to detect, once and for all, facts-accentuators. I would rather prefer to speak about the higher probability of some group of facts to attract attention.

In fictional worlds the semantics of events and facts can be much more precise. This is especially true with respect to the generic types of narratives, such as detective, western, superhero comics, etc. Not only are their plots constructed according to certain formulas, but also their storyworlds. They are repetitive and therefore predictable. In such narratives it is much easier to say beforehand what events or characters will become important. For example, the detective genre has very clear distinction between important and unimportant elements of the semantic sublevel of narrative structure. Such elements as murder, robbery, sleuthing, evidence, testimony, court and so on, obviously, belong to the category of potentially important narrative units, and readers are expected to pay additional attention to them, assuming that many of them may belong to the thematic structure. At the same time, in the detective novel such facts as romantic love or war are expected to have smaller accentuating potential. However, they may have strong accentuation meaning in some other genres, such as the romantic story or historical novel.

3.5 Syntactic sublevel of thematic structure → Semantic sublevel of thematic structure

Thematic facts can also be accentuated by means of the syntactic organization of thematic structure, by a specific "thematic syntax." The most thoroughly studied aspect of thematic syntax is "*story grammar*," studied by Rumelhart [28], Thorndyke [34] and others. Story grammar is an abstract formula implicitly present in a narrative text, the role of which is to simplify the process of text memorization and retrieval. For example, here is one part of a larger grammar proposed by Thorndyke (an arrow stands for "consists of" and an asterisk indicates that an element may be repeated):

1. STORY → SETTING + THEME + PLOT + RESOLUTION
2. SETTING → CHARACTERS + LOCATION + TIME
3. THEME → (EVENT)* + GOAL

One of the important elements of such structures is GOAL, i.e. a task that needs to be fulfilled by a character. Numerous experimental studies [7, 18, 24] came to the conclusion that the goals of characters are regarded as important by readers during text comprehension, and they pay additional attention to these goals. Thus, it could be assumed that GOAL is a syntactically accentuated narrative element, and a thematic fact attributed to the category of GOAL will be memorized better than the one attributed to the regular EVENT category. Also, it was shown by Lutz and Radvansky [24] that, although completed goals are less accessible in readers' memory compared to failed goals, they are still better remembered than neutral information.

Similarly, Greimas's *actantial model* [17] implies the distinction between accentuated and not accentuated units. This model consists of six elements:

1. subject,
2. object,
3. sender,
4. receiver,
5. helper,
6. opponent.

Subject and object form the main axis of the model, being the most important elements. However, such elements as sender or helper seem to correspond to the "less important" part of the scheme. (Of course, the importance of certain elements of the model is genre-dependent, so we should beware of too broad generalizations.) The opposition of "subject vs. helper," perhaps, is the most apparent example of the opposition "more important vs. less important," which may be translated into more traditional terms as "protagonist vs. secondary character." It should be stressed that this opposition is a completely formal structure: the thematic fact of a character being a protagonist is not something "natural," but merely a formal construction. For instance, in *Treasure Island* by R. L. Stevenson [35], Ben Gunn is a minor character in comparison to Jim Hawkins or John Silver. But in R. F. Delderfield's novel *The Adventures of Ben Gunn* [4], which is a prequel to Treasure Island, he becomes a major character. In other words, Delderfield in his novel organizes the syntactic structure of accentuation of the thematic level in a way different from Stevenson's, changing the importance of the roles of characters. In this case Ben Gunn is stressed much more strongly than in Stevenson's novel and therefore is expected to be much better remembered.

Another thematic syntactic structure of a similar kind is "*beginning – middle – end*," in which both beginning and end are marked as important, and the middle is not marked as such. I do not have experimental evidence to support this idea, but I can refer to some theoretical ideas of Yuri Lotman, who asserted that the beginning and ending are very important structural elements of the composition of an artistic text [22, p. 427]. A similar assumption was made in passing by Emmott, Sanford, and Dawydiak: "It may be the case that information embedded in the middle of a paragraph has less impact than information at the beginning or end of a paragraph, and likewise, it may be the case that information is handled differently depending on whether it comes at the beginning, middle or end of a whole story" [10, p. 217]. Unfortunately, this idea was not developed by these researchers, but the recurrence of this theoretical prediction is worth noting.

These are just three of the thematic syntactic structures that may be used for the accentuation of certain thematic facts. However, two aspects make me treat this topic very carefully. First of all, it should be mentioned that the accentuation of thematic facts is not very well studied; in particular, there currently exists not enough experimental support (although some claims, such as the one about the formal opposition "subject vs. helper," seem to be self-evident). Second, it is very important not to restrict oneself to the analysis of one text when studying the memorization of the elements of thematic structure. Thematic structure does not belong to the text itself; its elements may be accentuated in many different ways, and the text of a narrative itself is just one of the possible accentuators of it. The thematic structure of *Treasure Island* is accentuated not only by the numerous devices "inside" the narrative text, but also by means of some other texts functioning in the space of culture, such as film adaptations, cartoons, toys, etc. Thus, thematic structure should be studied already from the perspective of collective or cultural memory [1, 21].

Such accentuation by other texts in the body of culture may drastically change the thematic structure of a text. Perhaps, not many of those who have read Defoe's *Robinson Crusoe* recall that this novel contains not only the story of a man who tried to survive on a desert island, but also quite a long narrative (first five chapters of the book) concerning how Robinson ran away from home, made a journey to Brazil, became a slave, and had some marine adventures which finally led him to the desert island. However, these events are properly accentuated in the text itself. Such irregularity of recall can be explained by the fact that the cultural accentuation of the thematic structure of the novel is quite different from the accentuation exclusively by means of the novel itself. Different cultural texts concerning the story of Robinson (film adaptations, illustrations, retellings, etc.) usually accentuate only the part of the novel describing his life on the island. Perhaps, if the process of memorization was not influenced by all the additional texts, the thematic structure of the novel might have been quite different.

4 Conclusion

The current work represents an attempt to clarify some features of narrative structure that are interrelated with some specificities of the memorization of literary narrative texts. I have tried to show that there exist specific linguistic devices indicating to readers which elements of a text are important and should thus be memorized, and which of them are not. These devices may be called textual accentuations. Textual accentuations should be distinguished from the foregrounded text elements that also capture readers' attention. The former utilize the mechanisms of voluntary attention while the latter are based on the use of involuntary attention. The main goal of this article has been to describe the main principles of accentuation and construct a rough typology of accentuation forms.

At the present moment this typology is not very detailed and it may be rewarding to further develop it. Such development can go in two different directions. The first is investigation in depth – the search for further subcategories of the accentuation types presented in this article. The second direction would be in breadth – the search for accentuation mechanisms not only in literary narratives, but also in many other types of media, which were not covered in the present study. Logically, these other media should possess their own techniques for capturing the attention of readers/viewers/listeners.

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Modifying Entity Relationship Models for Collaborative Fiction Planning and its Impact on Potential Authors*

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Abstract

We propose a modified Entity Relationship (E-R) model, traditionally used for software engineering, to structure, store and share plot data. The flexibility of E-R modelling has been demonstrated by its decades of usage in a wide variety of situations. The success of the E-R model suggests that it could be useful for collaborating fiction authors, adding a certain degree of computational power to their process. We changed the E-R model syntax to better suit the story plans, switching the emphasis from generic types to instanced story entities, but preserving relationships and attributes. We conducted a small-scale basic experiment to study the impact of using our modified E-R model on authors when understanding and contributing into a pre-existing fiction story plan. The results analysis revealed that the E-R model supports authors as effectively as written text in reading comprehension, memory, and contributing. In addition, the results show that, when combined together, the written text and the E-R model help participants achieve better comprehension – always within the frame of our experiment. We discuss potential applications of these findings.

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1 Introduction

There have been many attempts to provide computational models for narrative and storytelling, pioneered by Propp's morphology of the folk tale [16]. Narrative models adequate for collaborative fiction planning should deal with several aspects. First, different kinds or genres of narrative need different types of rules, particularly, fiction draws strongly from the authors' creativity. Second, stories should be innovative and original. Computational models for stories often obstruct the creative development of the collaborating authors' contributions [17]. In this paper we introduce a narrative model flexible enough to support a wide variety of fiction stories while laying a strong foundation for all sorts of contributions supporting their internal coherence. Our proposed model is based on the Entity-Relationship (E-R) model, a well-established semantic data representation for database design by Chen[2], widely used in software engineering. It also draws part of its inspiration on Lehnert [10]

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high level analyses of stories in terms of plot units as arcs in a graph that encodes the plot of the story. The modified E-R model exploits the analogy between the requirements of an information system and the plans for a story. We introduce two key modifications; unstructured object representation and dynamic modelling. We also remove data abstractions and focus on instanced data. The proposed model should support authors' communication for collaborative fiction writing (CFW). As a first step we are interested in testing its impact on potential authors to determine if the modified E-R model has potential as a collaborative story planning tool.

In what follows, first we discuss more in detail our approach within supporting CFW plans. We argue the election of E-R amongst other popular semantic models, and the modifications performed to this model to make it suitable for storytelling. We then discuss the results of a small-scale basic experiment and their implications for CFW. A brief proposal for future work ends the paper.

2 A strategy to support authors in story planning

Within CFW, facts need to be communicated, coordinated and negotiated [12] amongst the writing team. On the other hand, and referring to CFW [9] states that "good extended story telling is constrained by the need to maintain consistency and coherence", as otherwise, poor consistency or coherence can easily lead to losing the suspension of disbelief which is generally accepted as an essential trait of successful fiction. Our own previous work on a *Story on a Wall* [4], a public shared board for collaborative stories, revealed three key factors for the participants/would-be authors: the need of understanding the structure of the story, a high concern for preserving the story consistency when contributing, and a generalized interest on keeping canonicity. Likarish *et al.* [11] state that the use of "a suite of authorship tools that provides quick access to pertinent details would be of immense value". Our next step was to experiment with a digital tool to create and explore multi-authored fairy-tales, *CrossTale*. *CrossTale* contained a rich interface to explore and create new scenes and an underlying (hidden) formal model that set the rules to preserve consistency in the authors' contributions. The results of the experiment [17] pointed towards the need to make more visible the hidden model, as the formal constraints imposed on authors would interfere with the CFW. A good tool for supporting CFW could be a model to plan the content of the story telling (a shared universe SU, in our terminology), visible to the authors, flexible, easy to understand while supporting communication, where consistency could be preserved both by authors and the formal model. We formalise further the desired characteristics of the model:

1. *Flexible symbol representation:* A symbol representation that creative fiction can adapt to the story instead of the story being constrained to the model; authors could change the rules or create new, more suitable ones for the story.
2. *Support for conceptually abstract symbol representation:* The model should be flexible to support both concrete elements of the SU such as characters or locations and more abstract ones, such as feelings or knowledge, and authors should be able to decide which items are elements or descriptors of other ones. This is not the same as abstract data representation, a common feature in computational models, as discussed later.
3. *Informative entity relationship network:* The model should allow authors to express relations between entities in an informative way, possibly through the usage of explicit predicates.
4. *Focus on instantiated data:* Authors would rather use specific characters, such as 'Bob and Larry' and 'how Bob relates to Larry' than 'two instances of character with name

attributes Bob and Larry' and 'how characters relate between them', respectively. Data abstractions could make the model more complex for authors. Next we discuss which model or modified model would fulfil these characteristics to support CFW.

3 Semantic models compared in terms of CFW support

Peckam and Maryanski [15] claim that the benefits of Semantic Models used in Computer Science are *Economy of Expression* (generically useful), *Integrity Maintenance* (very important for consistency and generating suspension of disbelief), *Modelling Flexibility* (whose importance has been indicated) and *Modelling Efficiency* and provided an extensive comparison amongst models commonly used. The capability to establish user-defined logic is positive with respect to *flexible symbol representation*, and allowing users to characterize the relationships and possibly represent them as separate entities is positive for expressing the *relationships network*; hierarchical structures would make the representations unnecessary complex, and there seem to be little advantages for authors in data abstraction, derivation and inheritance provided by entities, thus our focus on *instanced data*.

On this basis, Table 1 maps [15] comparisons to the characteristics introduced in the previous section, which are column headings, with color labels denoting the fitness for the characteristics: green, yellow, and red denote good, medium, and bad fit.

Thus, the Entity-Relationship (E-R) model is the most suited for the characteristics of CFW, and it could even be improved by introducing dynamic modeling (for better flexibility in symbol representation) and unstructured object representations (for enhancing the support to conceptually abstract symbols). The next section presents the E-R model as we modify it to support better CFW.

4 The E-R model modified to enable it for story planning

The E-R model [2] introduced comparatively long ago is still widely used by engineers to design data structures holding real-world input. It is necessarily flexible as its representation should cater for any kind of quantitative data set, regardless of its anatomy, as well as it should address any scenario.

More precisely system architects gather a so called requirements list for an information system and translate it into an E-R model through a process called data modelling; the output fits each requirement within a globally coherent system formally formulated. Our approach intends to exploit the analogy of 'requirements formulated as needs of users', and 'story plans of the authors' both expressed in plain structured English. We suggest that authors develop both the written story plan (in plain sentences) and the E-R diagram simultaneously, and maintain it reflecting the development of the story plan.

The E-R formulation we propose uses the elements of Chen's original model but with different meaning, as software engineering and story planning have different goals. We also attempt to introduce some of the desired characteristics resulting from previous analysis into the E-R model.

Entities represent the *agents* of the story. Any item with any degree of conceptual abstraction could fall into this category. In information systems entities usually denote classes or types, such as animal races or vehicle models. Stories deal with *specific* characters and thus we switch the focus from data *classes* to data *instances*. Instead of dealing with the generic class character, we'll be a character instantiated type many times, identified by some

Table 1 Computer Science Semantic Models compared in terms of CFW.

	Conceptually abstract symbol representation	Flexible symbol representation	Focus on instantiated data	Informative entity relationships network
Entity-relationship model	Structured Object Representation	User specific insertion/deletion constraints. No Dynamic Modeling	Low data abstraction supported. No derivation or inheritance supported	Network of user selectable relations independently represented
TAXIS	Structured Object Representation	User specific insertion/deletion constraints. Transaction and object-oriented Dynamic Modeling	Medium data abstraction supported. Inheritance supported	Strong hierarchical predefined relations represented as entity classes
SDM	Structured Object Representation	Automatic insertion/deletion constraints. No Dynamic Modeling.	High data abstraction supported. Derivation and inheritance supported	Generally hierarchical user defined relations represented as entity classes and independently
Functional	Structured Object Representation	User specific insertion/deletion constraints. No Dynamic Modeling	Medium data abstraction supported. Derivation and inheritance supported	User defined relations represented as functions (no support for hierarchies or networks)
RM/T	Structured Object Representation	Automatic and user specific insertion/deletion constraints. No Dynamic Modeling	High data abstraction supported. Inheritance supported	Generally hierarchical predefined relations represented independently
SAM*	Unstructured Object Representation	Automatic insertion/deletion constraints. Object-oriented Dynamic Modeling	High data abstraction supported. Inheritance supported	Network predefined relations represented independently
Event	Structured Object Representation	Automatic insertion/deletion constraints. Transaction dynamic Modeling	Medium data abstraction supported. No derivation or inheritance supported	Hierarchical predefined relations represented as attributes
SHM+	Structured Object Representation	Built in insertion/deletion constraints. Transaction dynamic Modeling	Medium data abstraction supported. Inheritance over generalization and association hierarchies	Generally hierarchical predefined relations represented as attributes and entities

attribute such as its name. Data abstractions such as generalizations or grouping are removed in order to focus on the instanced level of data. We are no longer dealing with *Characters* in this approach, instead we model Mike and the Butcher.

Relationships represent links between entities, for instance, informing of a fact, such as a contract of marriage between two characters. Since most story entities are instances, relationship cardinality is removed. If Mike and the Butcher have a relationship of friendship, it means implicitly that there is just one Mike and one Butcher. Adding a predicate (such as *marriage* or *friendship*) to the relationship is important to state clearly its meaning.

Attributes provide additional information regarding an entity or relationship. The common E-R formulation uses labels and values, but stories often provide little labels and only values, and entities rarely have any attributes in common. Thus, we avoid labels and store attributes as values. For instance, instead of having a personality attribute with *kind* as its value, a

Figure 1 Example of an information system E-R modelling.

character might have the attribute *kind*. This is more straightforward but less standardized in software engineering. This is not supported in the original E-R formulation, but a certain amount of unstructured object representation is beneficial for SUs.

The following example illustrates the differences between the information system and story planning modelling. *Employees have a Name and ID number. Every Employee has a Payroll assigned. Payrolls have a Gross income value and a Tax deduction value.* This might be modelled by an E-R diagram such as depicted in Figure1.

In a story plan, it is more likely to find a statement such as: *Mike is an unhappy employee with a poor payroll*, which could be represented through our modified E-R diagram (see Figure 2).

Figure 2 Example of a story planning E-R modelling.

Chen proposed a set of rules to translate system requirements formulated as English sentences into E-R diagrams [3], which can be used to translate explicit sentences from a story plan into its E-R model. Specifically the first four rules are simple and easy to use in the context of narratives. They convert *common nouns* into entity types, *transitive verbs* into relationship types, *adjectives* into entity attributes and *adverbs* into relationship attributes. The tenth rule proposed by Chen (meant to convert *clause sentences* into a group of interconnected sub-entities) can help in organizing nested plot data. We propose following a three-step strategy:

1. Formulate the story plan in plain explicit sentences; the narrative plan will be made of “story requirements”.
2. Translate the sentences into an E-R model using Chen’s rules [3].
3. Merge the E-R models and disambiguate any conflicts.

The merging process involves combining the new information with the one already modelled, and disambiguating any potential contradiction. It involves understanding the new entities and establishing their relationships to existing ones. It is a process that can be almost impossible to automatize or assist due to its subjective nature. For instance sometimes an entity must be transformed into another one, sometimes entities are duplicated or even merged. An author with a good conception of a story plan can perform such task (maybe even refining the concept). The ability to introduce insertion and deletion formal constraints could assist this process. This methodology might be beneficial to planning processes that involve more than one author, especially in fiction genres. Also this methodology could assist non-expert users in using an E-R model.

5 A small-scale basic experiment

The E-R model makes visible for authors the underlying formal model hidden in our previous experiments. Before using the E-R in a software prototype it was necessary to test some basic parameters of collaboration. We also measured contribution to attempt to triangulate with our previous results. The basic parameters were related to cognitive processes supporting collaboration: individual comprehension of a story potentially written by another author, and its recall. If comprehension and memory using E-R were degraded with respect to basic text, the model would be of little practical value. A secondary concern would be the time used by subjects to understand – again, if a much longer time was needed with E-R models, its potential would be minimal.

As a first step we compared the basic individual performance in reading, and contributing to, a story with or without using E-R diagrams. We used the first part of the *Stagecoach* movie synopsis (taken from the Spanish Wikipedia [18]), which seemed a rich enough but short story plan. A volunteer Computer Science graduate created the E-R model from this synopsis. 35 subjects (ages 20 to 65), who signed an informed consent form, were divided into three groups: experimental group 1 had both the text to read and the E-R model, experimental group 2 had only the E-R model, and the control group had only the text. Each group had approximately the same proportion of subjects with previous knowledge of E-R modelling (around 37%). Each subject received a brief training providing a basic understanding of our modified E-R modelling.

Every subject received the corresponding printed material and was given the briefing: *This is an incomplete story plan. Please read it.* This phase lasted as much as the subject felt necessary. Then we measured **comprehension** with a short questionnaire composed by open questions. The same group of judges who selected the questions (based on consensus about their usefulness to determine comprehension) was used to evaluate the answers, and we used free-marginal Kappa coefficients to determine the agreement among them. **Memory** was evaluated by removing the written material and asking subjects to answer a true-or-false questionnaire. Then we evaluated **contribution**: we returned the materials to each subject and gave them the following briefing: *We would like you to contribute to this story plan in any way you want to.* They were free to contribute as much as they wished, at any part of the original text or E-R diagram. **Time** spent in the different phases of the experiment was measured as an indicator of the efficiency of the model.

6 Result Discussion

Our experiment intended to perform a first assessment of the effect of introducing E-R modelling to support planning in collaborative fiction writing. Four main aspects were measured *Comprehension*, *Memory*, *Time* and *Contribution*, whose relevance with respect to CFW we discuss along with the results.

Comprehension. The ANOVA test reveals significant difference between the three group means with regards to comprehension ($p = 0.0132$ $F(2,30)=5.0075$). The post-hoc t-tests revealed no significant difference between the two groups with either text or E-R, but a very significant difference between each and the group with both. Enhanced comprehension likely means more *effective communication* amongst writers, which, along better *coordination* are according to Lowry *et al.* [12] two of the most fundamental processes of collaborative writing. The increased comprehension could be through reinforcement of dual cognitive channels, as proposed by Mayer in his Cognitive Theory of Multimedia Learning [13] (CTML). Another possible explanation to the increased comprehension might lie in the existence of the induced paths Corman *et al.* found in their work related to graphs [5]. In this sense, any graphical representation might achieve this positive result. The positive results together with the theoretical grounding encourage us to continue further. A substantial part (26%) of the group who only had the E-R diagram complained about the lack of a reading order – although we did not see its impact in the measures we took. However, this points at a limitation of E-R models, which usually represent *snapshots* of a data set, when transformations are a fundamental part of stories; we already identified this requirement in a previous section. While representing transformations is somewhat opposed to the nature of standard E-R models, using multiple E-R models, perhaps one per chapter, episode or page, could provide an answer to this problem. Another alternative would be a viable syntax to map the transformations and story progression into one single E-R model, such as the one proposed by Klopprogge [8]. 21% of the subjects provided with the E-R model complained about the confusing syntax of relationships; the roles in relationships were removed (e.g. which character hates and which one is hated in a hate relationship), and this makes a story harder to understand. We did not anticipate this, and using Chen's original relationship role labelling or Corman *et al.*'s approach [5], introducing directed networks of relations, would make the E-R model more understandable for story planning, without compromising simplicity and flexibility. Some E-R experts fixed the diagrams, and some people fixed the text. This might be an indicator of users' motivation for quality / consistency [9]), and is consistent with our previous experiments with Story on a Wall and CrossTale; but it might be due to other factors, such as professional rigor. While the pre-existing knowledge on E-R models surely impacts on the results, the proportion of experts in each group was balanced, so that the differential results would be valid, within the confidence ranges allowed by the quite small numbers of the experiment.

Memory. Despite differences in comprehension, there were not significant differences amongst the groups regarding memory (ANOVA p=0.9341 F(2,30)=0.0682). Knowledge retention could boost the coordination between authors, and Nesbit & Adesope [14] registered its increase through the use of concept maps, which are similar to semantic networks. We need to address this issue in the context of more realistic, long time, conditions of CFW.

Time. Time results are difficult to interpret within a creative context. At a basic level shorter time might be an indicator of some alternatives being more or less efficient than other ones. The average time duration for the training phase was of 2'36" (sd= 28"), and without significant difference between the two groups with E-R. There was a significant difference in reading time among the groups (ANOVA p=0.0016 F(2,27)=8.2061). A post-hoc analysis using t-tests in pairs revealed no significant difference between the groups only text and only E-R, but each of them had significant difference with the group using both materials, which took longer. Viewing the results together, there are no differences in comprehension, memory and reading time for the groups with only text and only E-R, which seems to point towards E-R being a viable alternative to text. The increase in reading time of the group with E-R and text resulted in increased comprehension: as the important point for CFW at a basic level is comprehension, this points towards using both text and E-R for future work. While there were differences among groups, the correlations of comprehension and memory with reading time for individuals were not significant.

Contributions. 6% of the subjects chose to make no contributions There were not significant differences among the three groups in contribution time (ANOVA p=0.9346 F(2,18)=0.0677—2 or 3 subjects per group removed as they took much longer). There was a very weak positive correlation (coefficients ranging from 0.36 and 0.5) between reading time and 1) *word count* for text contributions, 2) *new entities* for E-R contributions, 3) *new but related entities* for E-R contributions and 4) *total new characters* introduced for all the contributions. All the individuals who received only text contributed using text. From the individuals who received only the E-R model, 23% contributed using text and 69% used an E-R diagram—a much higher percentage than experts, around 30%. The individuals in the group that received both E-R and text contributed equally along formats (30% used text, 30% used E-R and 40% used both formats). There is a strong positive correlation between *text contribution word count* and *E-R contribution attributes and relations introduced* for subjects who contributed both text and E-R diagrams (coefficients around 0.8), broadly indicating that they contributed in similar proportions in both ways – not privileging one of them. This leads to suspect that they did it in parallel, textual content corresponding with larger E-R diagrams. At the more basic level, E-R models look as efficient as text, and seem simple enough to be used by an important proportion of non-experts after a very short training. The experiment was oriented towards understanding basic issues in preparation of larger experiments where productive creativity can be tested. At this stage, the different models did not look different in supporting creativity. We did not analyse qualitatively the contributions, and this would be an important for further research in CFW.

The results of the experiment indicate that E-R models are not worse than text in terms of comprehension of the story or recall, the basic cognitive processes supporting collaborative authoring. Using both E-R and text improves understanding, but it requires more time. Thus we can confidently proceed with a large scale collaborative authoring experiment based on E-R models supported by a software prototype. In terms of contributions, we could not triangulate with our previous results. However, a significant portion of subjects without expertise in E-R modelling, and with only an extremely short training, spontaneously contributed using E-R– which is also a positive sign of the potential of the approach.

7 Future work

As indicated earlier, support for the temporal dimension seems key because of the transformational nature of stories, and adding roles to the relationships is also necessary. On the other hand, our modified E-R model could be extended to include recent E-R improvements such as the ones proposed by Hartmann *et al.* [6]. A certain degree of semantics and data structures could be introduced to streamline story planning and assist the authors in their task, without compromising the model flexibility and the authors' predominant role. A clear first step is the introduction of insertion and deletion constraints, optional for authors, as used in our previous CrossTale tool [17]. The model introduced could be used to gather more easily data on the author's construction of the story, seen as important by AI practitioners [1]. This could be used to provide authors with tools that predict and support their needs and actions. If a large-scale is achieved, the data gathered through the model could contribute to build from experimental data computational models of the morphology of different genres (our example was based on a western), just like Propp [16] proposed his morphology for traditional folk tales. Genre/writing technique templates could also provide skeleton frames to support authors during inspirational or creative blockings. The story plan used in the experiment was rich enough, but relatively small when compared to a real site of CFW such as [7]. Scalability of the E-R model is one of the issues to be tested in a more realistic CFW experiment or setting. And in this setting exploiting the computational characteristics of the model to support story coherence, as well as quality of the contributions—indicated earlier—will be paramount. Story telling has been recently acknowledged as an important component of visualization [1]. Reciprocally, generating rich visualizations when the plans or stories expressed through E-R models could help authors and, on the other hand, provide researchers with information to prepare enhanced tools based on predictive models, where clustering techniques will probably be used.

The next experiment we are currently preparing is a web-based large-scale longitudinal collaborative fiction writing aimed at producing stories on a shared universe (its basics already developed). Based on this paper results, the story plan tools will be (formal, not only visual) E-R with improved relationships and plain text. Inter-author communication and visualization of complex story plans will be also used. The focus will be on measuring quantitatively and qualitatively the contributions and some specific aspects are author collaboration dynamics, creativity and consistency / coherence monitoring. At its initial stage the experiment might not be using dynamic models yet.

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A Story seed text

In 1880, a motley group of strangers boards the east-bound stagecoach from Tonto, Arizona Territory to Lordsburg, New Mexico Territory. These travelers are unremarkable and ordinary at first glance. Among them are Dallas, a prostitute who is being driven out of town by the members of the "Law and Order League"; an alcoholic doctor, Doc Boone; pregnant Lucy Mallory, who is traveling to see her cavalry officer husband; and whiskey salesman Samuel Peacock. When the stage driver, Buck, looks for his normal shotgun guard, Marshal Curly Wilcox tells him that the guard has gone searching for fugitive the Ringo Kid. Buck tells Marshal Wilcox that Luke Plummer is in Lordsburg. Knowing that Kid has vowed to avenge the deaths of his father and brother at Plummer's hands, the marshal decides to ride along as guard. As they set out, U.S. cavalry Lieutenant Blanchar informs the group that Geronimo and his Apaches are on the warpath and his small troop will provide an escort until they reach Dry Fork. As they depart, the stagecoach is flagged down to pick up two more passenger, gambler and Southern gentleman Hatfield as well as banker Henry Gatewood, who is absconding with $50,000 embezzled from his bank. Along the way, they come across the Ringo Kid, whose horse became lame and left him afoot. Even though they are friends, Curly has no choice but to take Ringo into custody.

B Story seed E-R diagram

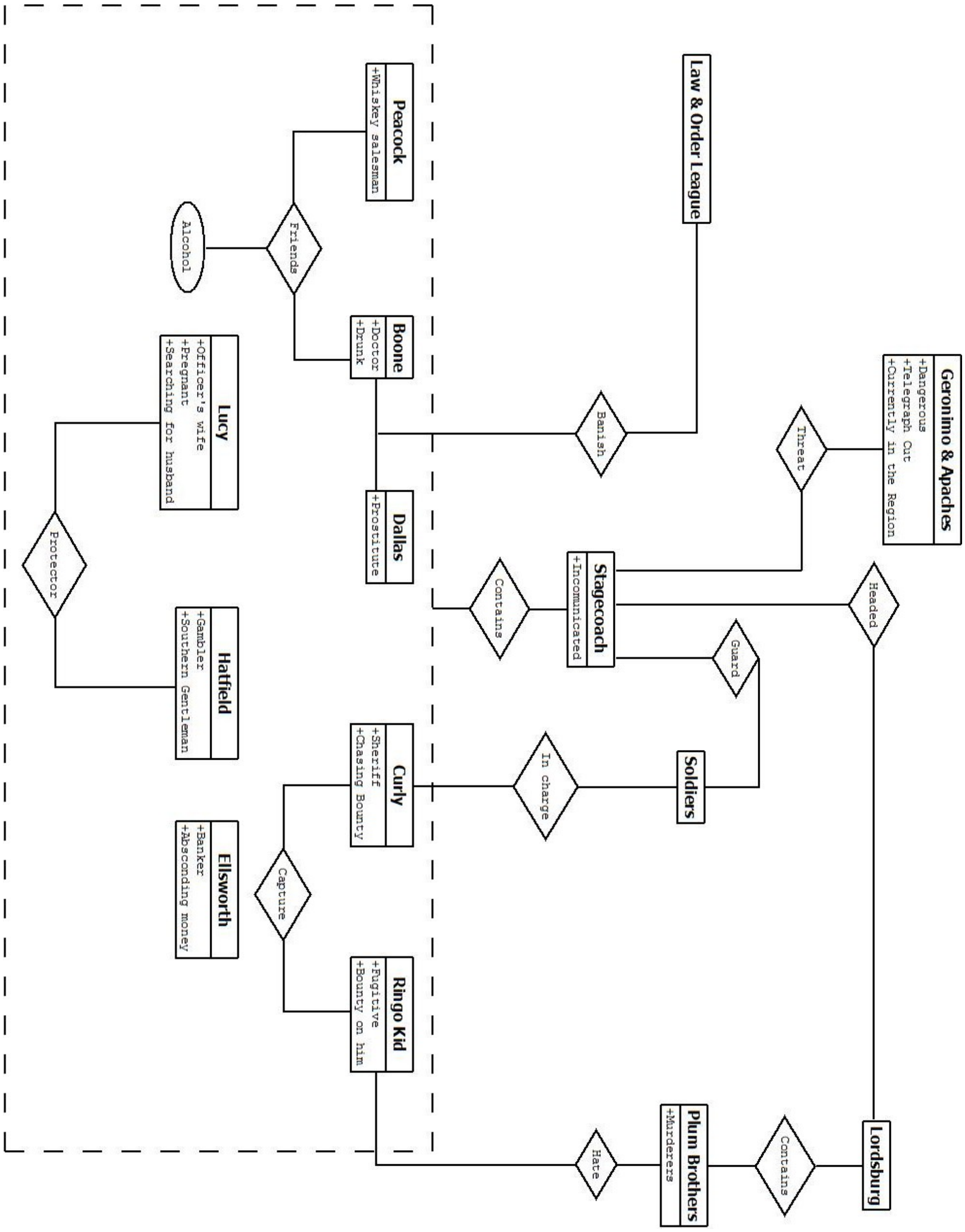

Figure 3 Story seed E-R diagram.

C Result tables

Table 2 Average time spent in the different phases.

	Reading phase	Comprehension test	Memory test	Contribution phase
Text group	124 seconds σ=52.8	261 seconds σ=80.5	70 seconds σ=35.4	288 seconds σ=133.4
E-R group	142 seconds σ=72.4	233 seconds σ=71.6	92 seconds σ=31.2	272 seconds σ=111.7
Text + E-R group	236 seconds σ=69.6	315 seconds σ=107.5	93 seconds σ=34.2	293 seconds σ=92.5

Table 3 Time used in the comprehension phase.

Text vs. E-R	Text vs. Text+E-R	ER vs. Text+E-R
p=0.5170 (no significance) t=-0.6625	p=0.0011 (very strong significance) t=-3.9894	p=0.0101 (strong significance) t=-2.8756

Table 4 Memory and comprehension test averages.

	Comprehension test (0 to 3 points)	(Memory test (0 to 9 points)
Text group	2.325 points σ=0.329	7.417 points σ=1.443
E-R group	2.254 points σ=0.438	7.384 points σ=1.387
Text + E-R group	2.680 points σ=0,167	7.5 points σ=1.354

Table 5 Comprehension test judge agreement.

Average item-total rating correlation	Overall agreement Po %	Fixed-marginal kappa	Free-marginal kappa
0.8900	0.6647	0.3602	0.553

Overall Result: *Moderate agreement*

Table 6 Comprehension test t-tests.

Text vs. E-R	Text vs. Text+E-R	ER vs. Text+E-R
p=0.6124 (no significance) t=0.5150	p=0.0046 (strong significance) t=-3.259	p=0.0088 (strong significance) t=-3.0763

Table 7 Average contribution per group.

Text contributions	**Word count**	**Sentence count**		
Text group	74.6	4.6		
E-R group	56	2.6		
Both group	80.7	4.3		
E-R contributions	**Entities introduced**	**Attributes introduced**	**Old entities related**	**New entities related**
Text group				
E-R group	0.8	1.9	4.1	1.1
Both group	0.5	0.9	5.6	1.6
Overall contributions	**Old characters used**	**New characters introduced**		
Text group	5.2	0.3		
E-R group	3.4	0.5		
Both group	5.5	0.5		

A Cognitive Framework for Understanding Counterintuitive Stories

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Abstract

Stories containing counterintuitive concepts are prevalent in a variety of cultural forms including folktales, TV and radio commercials, and religious parables. Cognitive scientists such as Boyer [2, 3] suggest that this may be because counterintuitive concepts are surprising and more memorable for people and therefore are more likely to become widespread in a culture. How and why people remember such concepts has been subject of some debate. This paper presents studies designed to test predictions of the context-based model of counterintuitive story understanding.

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Keywords and phrases counterintuitive concepts, memory

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1 Counterintuitive Stories

Why do some stories become widespread while others die soon after their creation? Memorability has been considered to be an important variable that explains some of the differences in distribution of cultural concepts. Everything else being equal, stories that are easier to remember and recall are more likely to be transmitted. Systematic studies of story memorability started with Bartlett's classic studies [1]. In a series of experiments, Bartlett asked British university students to read passages from various folk tales including the Native North American folk tale "the war of the ghosts" and retell it to others in writing who then retold it to others. Bartlett analyzed the transformation of various concepts over successive retellings. He found that culturally unfamiliar concepts such as canoe and ghost are more difficult to represent in human memory and therefore they are more likely to get distorted. Kintsch and Greene [7] compared distortions in retellings of an Apache stories with a Grimm Brothers' story and found that Grimm Brothers story was better preserved because it conformed to the structure expected by their subjects.

Recent studies by cognitive scientists of religion directly compare recall rates of intuitive and counterintuitive concepts to see if there are any differences between different types of stories. Barrett and Nyhoff [8] repeated Bartlett's methodology using six Noth American Native folk tales of about 500 words, containing both intuitive concepts such as the river and counterintuitive concepts such as a talking bird. They found that recall rates for counterintuitive concepts were significantly higher than recall rates for intuitive concepts. Barrett and Nyhoff also designed an artificial story to better control for the number of intuitive and counterintuitive concepts, narrative structure, and the amount of repeated exposure to a concept. The futuristic story about a person visiting a museum to see alien beings and artifacts was designed to contain six concepts of each of the following three types:

1. *intuitive* (INT) concepts that conform to reader's expectations about base categories of given concepts such as a being who is aware of its existence,

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2. *minimally counterintuitive* (MCI) concepts such as a being who never dies that violate one intuitive expectation of members of the base category. MCI concepts are contrasted with *maximally counterintuitive* (MXCI) concepts such as a being that can read every one's mind, never dies and is invisible, and
3. *bizarre* concepts that do not violate any category expectations but have an unusual feature value such as a being who weighs 1000 pounds.

They found that after three retellings, counterintuitive concepts were better recalled than bizarre concepts which were better recalled than intuitive concepts. Boyer and Ramble [10] used a variant of Barrett and Nyhoff's alien museum story but did not use a serial reproduction task. Instead, they had subjects read a story and following a brief distraction task answer a question requiring reproduction of as many intuitive, counterintuitive and bizarre items mentioned in the story as the subject could recall. Their results supported Barrett and Nyhoff's conclusion that minimally counterintuitive items are best recalled and the intuitive items are worst recalled. However, none of these studies addressed the question of whether stories containing minimally counterintuitive ideas are recalled better or not? i.e., does the presence of minimally counterintuitive ideas also improve story recall?

Norenzayan et al. [11] conducted experiments to address this questions. They selected 42 Grimm Brothers folktales such that half of the stories were judged to be "culturally successful" (they attained more hits on 400 world wide web Google searches) and the other half were considered to be "culturally unsuccessful" (because they had fewer Google hits). The numbers of counterintuitive ideas present in each story were then counted. They called stories containing 1 or more counterintuitive idea *counterintuitive stories*. The results indicated that a large majority of the folk tales deemed culturally successful had two or three counterintuitive ideas whereas the number of ideas was more distributed from none to six. Norenzayan et al. argued that stories that contain two or three counterintuitive ideas enjoy memorability advantages over stories that have fewer (0 or 1) or more (4, 5, 6, or more) counterintuitive ideas. Norenzayan et al. did not directly measure the recall rates for stories containing various numbers of counterintuitive ideas. Upal [12] wrote three short stories of about 400 words each to directly test Norenzayan et al.'s predictions. Variations of two of the stories, namely, "The Journey Home" and "The Trader" had been used in previous experiments. Three versions of each story were created. Version I had one counterintuitive idea, while the second version had three and the third version had six counterintuitive concepts in it. Contrary to Norenzayan et al.'s predictions, Version II stories were not found to be more memorable than Version I and Version III stories. Follow-up studies carried out using Aesop fables and Aesop-fable-like artificial stories (such as the "Obscurity brings safety" story presented in the next section) found global cohesion among elements of a story (especially the counterintuitive concepts) to be a better predictor of story recall [12]. This makes sense given decades of psychological work on memory for texts [13] [14]. The results are also in line with findings by Harmon-Vukic & Slone [36] that text-integration overcomes the memorability advantages of counterintuitive concepts.

1.1 Context Versus Content-based Views

Discourse analysis researchers and psycholinguists have identified global cohesion among the elements of a text as a key factor in memorability of the text [15]. Cohesion of a piece of text is defined as connections among various elements of the text and is not just a function of the text itself but also of the background knowledge that the reader possesses. The connections that make a text more or less cohesive include coreferences as well as causal and logical connections among its various elements. A text is better remembered by a reader if its constituents can be made coherent by the reader [16]. Furthermore, the more effort a reader spends in making a text coherent, the more memorable the text for that reader [17]. Building on this and other work in cognitive science of learning [18, 19] and humor [20], I hypothesized that counterintuitive ideas contribute to making a story more coherent by drawing the reader's attention and by getting them to spend more time on the story trying to make it coherent [21]. This account suggests that, similar to other expectation-violating and schema-incongruent concepts [18] and distinctive stimuli [39], counterintuitive ideas are better remembered because they attract a reader's attention by violating the reader's expectations about what is to come next in the text. When a reader's expectations are violated, she attempts to resolve the inconsistency by reasoning to justify the inclusion of expectation-violating information in the text by invoking her background knowledge. If this postdiction effort is successful, the expectation-violating concepts become richly linked to the reader's existing mental representations. They also become richly connected to the derived story theme itself. This makes counterintuitive stories (and counterintuitive concepts) more memorable than intuitve stories and concepts. However, when the postdiction effort fails, the counterintuitive story and concepts embedded in it are not remembered well. This is what Vukic, Upal, & Sheehan [36] found when we compared recall rates for MXCI concepts with those of MCI concepts. We found that despite taking more time to process, MXCI concepts were not recalled as well as MCI concepts by people.

The postdiction process is a crucial component of the context-based model. It can employ a reader's prior world knowledge as well as the knowledge provided to it in the context in which the concepts are presented. The emphasis on the role of the contextual knowlede has led to the characterization of this view of the memory for counterintuitive stories as the *context-based* view [34, 12]. This view has often been contrasted with that of Barrett [6], which has been labeled as the *content-based view* because it de-emphasizes the role played by the contextual knowledge as it seeks to understand those concepts that are cross-culturally memorable.

To better understand the context-based model, consider the following story (a version of which was used in experiments reported in [12]).

Obscurity Brings Safety

> Once, a man, who was invisible, ran into a woman who could see invisible objects. The all-seeing woman said what is a beautiful man like you doing being invisible. Were you visible, no maiden could refuse you. You are missing out on all the fun. On hearing this, the invisible man decided to have his body painted with skin color so that people could see him. On his way home from the paint shop he was mugged and wished that he had remained invisible as obscurity brings safety.

When readers read the concept of a man, it activates their mental concept of man which activates related concepts including the concepts of having a physical body which can be seen. However, upon finding out that the man is invisible, the expectations of such readers are violated and they engage in the justification process to explain reason(s) for this expectation violation. The readers may reason that this story belongs to the genre of moral fables[1] and use their world knowledge about fables to infer that fables often involve supernatural

[1] Readers do frequently (and for the most part successfully) infer genres by reading text even when such information is not obvious and use this information to reason about the text [23].

characters which are employed to illustrate a useful truth[2]. Furthermore, the reader can justify the man's invisibility as needed to support the story's plot. This successful justification process results in rich encoding for the counterintuitive concept as well as the coherent story ensuring their easy retrieval in the future. Contrast the above story with the following story of similar length and title and containing the same number of counterintuitive concepts:

Obscurity Brings Safety

> Once a man who had feet instead of hands ran into a woman who was made of iron. The iron-woman said what is a beautiful man like you doing being difficult? Were you not difficult, no maiden could refuse you. You are missing out on all the fun. On hearing this the man with four feet decided to have his body painted with skin color to become more attractive. On his way home from the paint shop he was mugged and wished that he had not done that as obscurity brings safety.

In this story, although the reader's expectation about a person having only two feet is violated, readers may be unable to construct a justification for this violation even in the context of a fable since the expectation violation is not helpful for illustrating the story's moral lesson. This means that the concept of man-with-four-feet should not be recalled as well as the concept of invisible-man. This is what was found [12] as people recalled those concepts whose inclusion could be easily justified more frequently than those concepts which were harder to postdict in the given context. The context-based model also predicts that:

- Determination of unexpectedness and coherability is a function of a broad set of contextual conditions. The contextual conditions include the background knowledge that the agent possesses prior to learning the new information [24], the agent's motivation [25] and the resources (such as time) available [26] to comprehend the information. Changing, any or all of these contextual factors can affect a concept's memorability and different concepts may be more or less memorable for different people in different situations. This is the prediction that we attempted to test directly through a number of experiments with human subjects. Findings to date have generally supported the context-based model [21, 28, 27, 36].
- Activation of a counterintuitive feature should also prompt activation of other counterintuitive features that are strongly associated with it (presumably because counterintuitive features also tend to co-occur in the agent's information environment). Thus observation of one counterintuitive property should prompt an agent to expect more counterintuitive properties. Thus a statue that speaks English should also be expected to understand English by a reader in whose semantic memory speaking and understanding are strongly connected to each other.
- Not all INT/MCI/MXCI concepts may be equally well remembered. Some types of INT concepts may be better remembered than other types of INT concepts (or even some MCI/MXCI concepts), some MCI concepts may be more memorable than other MCI concepts, and some MXCI concepts may be more memorable than other MXCI concepts (or even some INT/MCI concepts).

To be fair, proponent of the content-based view, including Barrett [6], do not claim that all concepts are unaffected by a changing context, rather that an interesting subset is. They further argue that such culturally invariant concepts are what cognitive scientists of

[2] Merriam-Webster Dictionary defines fable as, "a fictitious narrative or statement: as a: a legendary story of supernatural happenings b: a narration intended to enforce a useful truth"

religion should be interested in. These are the concepts that all people around the world learn through normal developmental processes. Barrett divides the knowledge that people learn through these maturationally natural processes [30] into six domains of universality, spatiality, physicality, biology, animacy, and mentality. He provided a table describing the six intuitive expectation-sets for the above categories (see Table 1). Barrett argued that each proposition in the table is supported by developmental psychology studies (page 213: [6]).

Barrett [6] admits a limited role for context when he argues that objects classified into each of these domains share properties that are so internally coherent that transfer of a single property from one expectation-set should be considered equivalent to the transfer of the entire expectation-set. Thus multiple violations involving the same expectation-set should be considered equivalent to one expectation violation (page 331: [6]). Since, growing, eating, and being alive are all drawn from the biology expectation-set, the concept of "a rock that grows, eats and is alive" should be considered to have the counterintuiveness score of one and thus should be considered minimally counterintuitive argues Barrett. I believe that this is a step in the right direction, but it does not go all the way in fully appreciating the role of context. Thus, for instance, according to the context-based view, as multiple counterintuitive properties from the same domain (e.g., grows, eats, and is alive) are added to a concept (e.g., rock) the new conceptual combination may indeed be so coherent that it may actually be perceived by some to be more intuitive than a concept with a single expectation violation. This paper reports on studies carried out to empirically investigate people's intuitive expectations for concepts identified by Barrett as relevant to cognitive science of religion, and test predictions of the context-based model that all concepts are impacted by context including those identified by Barrett.

2 Experiment 1

This study was designed to form a baseline of people's expectations for various concepts of interest to cognitive scientists of religion. We adopted the techniques used by feature-norming studies [33, 32, 31] to elicit people's expectations about features three object categories of rock, plant, and person. Rocks, plants, and persons are instances of solid objects, living things, and mental beings respectively. We used lower level concepts as previous research has found that participants have a hard time generating features for more abstract categories [31].

2.1 Participants

Participants included 153 adult males and females from across the globe who completed the online study through Mechanical Turk for a small remuneration. Three participants failed the attention check question (the question asked participants, "please do not click here") and thus were excluded from all subsequent analysis.

2.2 Material & Procedure

The materials consisted of an online form that listed the three concept names with each concept followed by a text field. Using the instructions developed by McRae et al. [31], we asked participants to type in as many properties of each of the four concepts as they could think of in the text-box that followed each concept.

Table 1 Barrett's Intuitive Expectation Sets.

Category	Properties
Physicality	Cohesion (move as connected whole)
	Contact (physical contact required for launching or changing direction of movement)
	Continuity (movement is continuous in space)
	Solidity (cannot pass through or be passed through by other solid objects)
	Tangibility
	Visibility
Biology	Growth & development
	Like begets like
	Natural composition
	Nourishment needs and processes to satisfy those need
	Parts serve the whole to sustain life
	Vulnerability to injury & death (if animate, seeks to avoid injury & death)
	Kind-specific essence
Animacy	Goals
	"Self-propelled" (including moving in space, changing appearance, emitting sounds, etc.)
Mentality	Reflective & representational mental states (e.g., beliefs, desires) and standard relationships among them and limitations of them (e.g., limited perceptual access)
	Self-awareness (including emotions and epistemic states)
	Understand language & communication
Universals	Consistency (assumptions apply continuously; past was like present, future will be like present)
	Time (and hence, causation) is unidirectional

2.3 Results & Discussion

The participant responses were coded by following a two-step process. The first step involved creating semantically similar clusters for features produced by participants. Thus the following participant responses to features for the category rock

- "is weighty",
- "is heavy",
- "weighs a lot",
- "has weight"

were all put into one feature labeled "is heavy." Once the most representative feature labels had been created, the second step was carried out. This involved assigning a 1 if the participant was judged to have indicated the feature and assigning a 0 otherwise. Each category feature was assigned a weight by computing the average coded value. Thus, a category feature that was indicated by all 150 participants would be assigned a value of 1, and a feature not mentioned by any participant would be given a zero weight. The category features were ranked by weight from the most prevalent to the least prevalent.

The results are shown in Figure 1 to Figure 3. They show that a majority of participants agreed on the feature hard for the category "rock." A minority of participants in Experiment 1 had also found "is hard" to be the most prevalent feature of the abstract category "solid object." Participants also listed additional features' e.g., "has minerals," "is round/smooth," "used to build things," "gray" in the case of rocks, "absorbs sunlight," "needs water," and

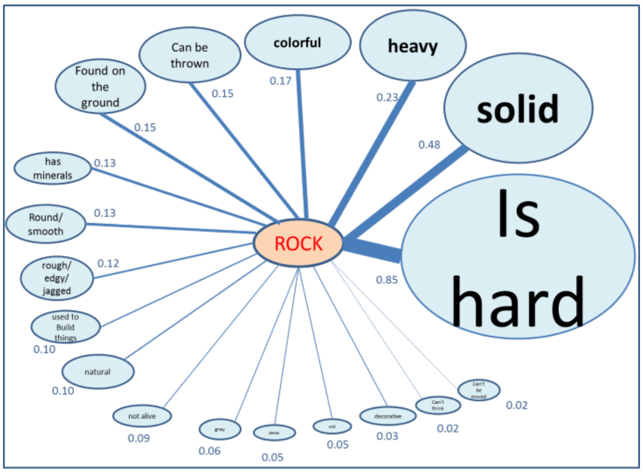

Figure 1 Most commonly mentioned features of the category rock along with the proportion of participants who mentioned it (indicated as a weight for a node).

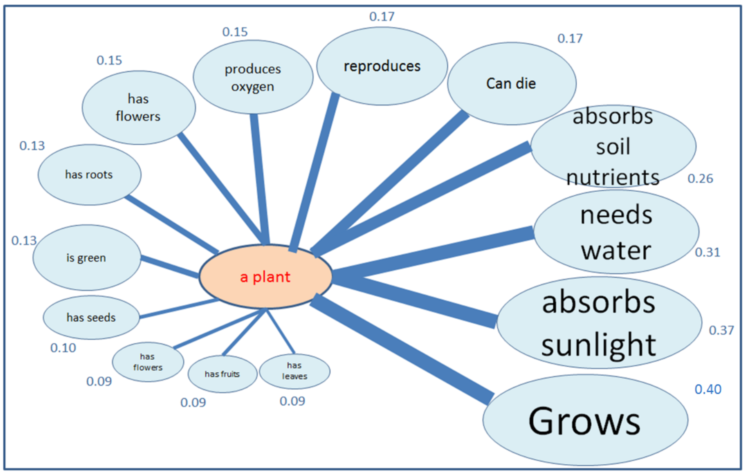

Figure 2 Most commonly mentioned features of the category plant.

"absorbs soil nutrients" in the case of plants, and "has hands/feet," "has eyes/ears," "has heart/blood" in the case of "person" that are not salient features of their superordinate categories. Almost half the participants also agreed that "a plant" grows.

The features that our participants generated for the category plant were similar to Ashcraft [33] who used a different question and only gave participants 40 seconds per word to write down properties. Ashcraft only listed top 5 features which included green, leaves, flower, grows, and stem.

3 Experiment 2

This study was designed to investigate changes in people's category expectations upon hearing of a counterintuitive feature along with one of the categories from Experiment 1.

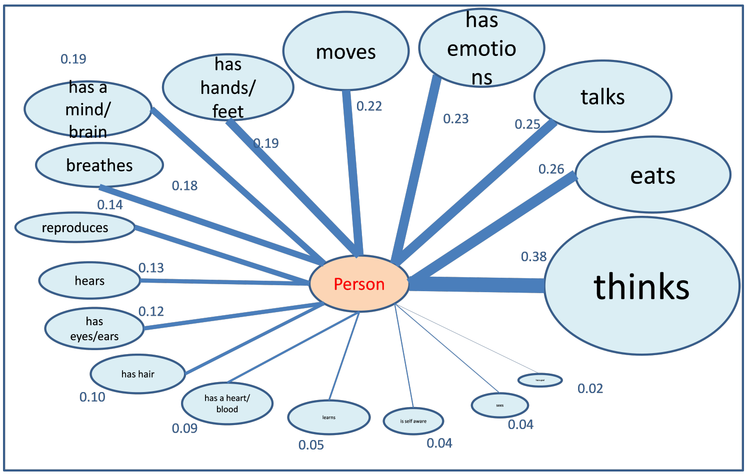

Figure 3 Most commonly mentioned features of the category person.

3.1 Participants

Participants included 153 adult males and females from across the globe who completed the online study through Mechanical Turk for a small remuneration. Three participants failed the attention check question (the question asked participants, "please do not click here") and thus were excluded from all subsequent analysis.

3.2 Materials and Procedures

The materials consisted of an online form that provided participants a category name and a counterintuitive feature and asked to list any other properties and features of the counterintuitive object they could think of. The following properties derived from Barrett's [6] animacy and mentality domains were included for both rock and plant because they were thought to be counterintuitive for both categories.

- eats food
- can see
- can talk
- can hear others
- sings
- has strong beliefs
- can understand others
- has emotions
- is self-aware

In addition, the following three biology properties were included for only the category rock.

- grows
- produces offspring
- can move by itself

Since both animacy and mentality properties are intuitively expected of persons, we included the following six counterintuitive properties for that category.

- can walk thru walls
- can see thru walls
- can hear from miles away
- can fly
- can leap over skyscrapers
- is invisible

3.3 Results & Discussion

The participant responses were coded by following a two-step process followed in Experiment 1. The top ten feature participants most commonly listed for various counterintuitive concepts involving the concept of rock are shown in Table 2. When we compare it to the features most commonly mentioned when presented with the concept of rock alone without any counterintuitive features (Figure 1), we find that people's expectations have significantly changed.

Looking down Column 1 of Table 2 shows that the feature most strongly associated with the category "rock" (namely, "is hard") by a whopping 85% of our participants is now the 6th most frequently mentioned feature with only about 1 in 20 participants who saw "rock that grows" mentioning it. The second most frequently mentioned feature of the category "rock" namely, "is solid" (listed by almost half of the participants who saw only the base category name) is now only mentioned by 1 in 12 participants who saw category rock combined with the property grows. Looking across top rows of Table 2 shows the powerful effect of context as "thinks" is the most frequently listed feature of rock concepts combined with various counterintuitive properties while it was not mentioned by any of the participants who saw base category name alone (as shown in Figure 1). According to the context-based view, this happens because activation of a counterintuitive property (e.g., hears) results in activation of features that are most strongly associated with it (talks, thinks, hears, and has ears). The top ten features participants most commonly listed for various counterintuitive concepts involving the category "plant" are shown in Table 3. It shows a significant shift in people's expectations as a result of hearing a single counterintuitive property being associated with the category plant.

The remarkable similarity between features generated by participants for the seemingly unrelated base categories of rock and plant (shown in columns of Table 2 & Table 3) shows the impact that activation of counterintuitive properties has on people's expectations. Thus the top two features of "rock that can hear" and "plant that can hear" are "talks" and "thinks" and are listed by almost the same percentage of participants across both categories. Similarly, the properties of "listens," "has ears," "has emotions," "is self-aware" and "is alive" were listed by similar proportions of our participants regardless of the base concept. There are also a few notable differences between Tables 2 and 3. These differences illustrate the impact of the two base category labels and the interaction between the category labels and the counterintuitive properties. Thus while the feature "grows" is only mentioned by participants who saw the property "eats food" added onto the category rock, it was mentioned by participants who saw any counterintuitive property added onto the category label "plant" (even though it does not show up among the top 10 features for "plant that has emotions" it was mentioned by 1% of the participants). This is because "grows" is the most frequently listed feature of the category plant (Figure 2) but not of the category rock (Figure 1). Thus when a feature is strongly connected to both the base category (e.g., plant) and the counterintuitive property (e.g., eats), it is strongly activated by the conceptual combination of the category label and the counterintuitive property (e.g., 44% participants listed it for "plant that eats"). When the feature is only connected to one of the two, however, it is only weakly activated. Thus "grows" is only mentioned by 19% of the participants in response to the combination "plant that can see" and "plant that is self-aware." Similarly, it is listed by 20% of the participants in response to the combination "rock that eats food."

The top ten feature participants most commonly listed for various counterintuitive concepts involving the concept of persons are shown in Table 4. Similar to the results for rock and plant concepts combined with counterintuitive properties, people's expectations for person concepts have significantly shifted as "is strong" becomes the most frequently mentioned feature even though it wasn't mentioned for the category person by any of our participants. The results support the context-based view that people's expectations

Table 2 The 10 most commonly listed features of the various counterintuitive conceptual combinations involving the rock concept. The percentage of participants who mentioned each feature is indicated in parenthesis.

Rock that					
grows	**produces offspring**	**can move by itself**	**eats food**	**can see**	**can talk**
gets bigger (14)	eats (22)	roll (19)	grows (20)	thinks (14)	thinks (22)
moves (14)	mates (18)	is solid (15)	digests (17)	moves/acts (12)	communicates (19)
eats (10)	moves/walks (16)	eats (10)	poops (16)	is fictional (12)	hears (14)
is solid (8)	is alive (13)	can walk or run (8)	drinks (12)	is solid (11)	moves (11)
is round (6)	is solid (10)	reproduces (7)	is alive (12)	eats (8)	has emotions (10)
is hard (5)	is human (6)	is alive (7)	has a mouth (10)	is hard (7)	is fictional (8)
is fictional (5)	has emotions (5)	is hard (5)	gets hungry (9)	is round (6)	is solid (7)
is alive (5)	is fictional (3)	is round (5)	can die (8)	is rough or edgy (6)	eats (5)
can reproduce (3)	is round (3)	has emotions (4)	can reproduce (8)	has emotions (5)	has a mind (5)
can die (3)	is hard (1)	has wants or desires (4)	breathes (8)	is self-aware (5)	I alive (5)

Rock that					
can hear others	**sings**	**has strong beliefs**	**can understand others**	**has emotions**	**is self-aware**
talks (22)	talks (30)	thinks (23)	thinks (33)	thinks (21)	thinks (34)
thinks (19)	thinks (13)	has emotions (15)	talks (20)	can be happy (12)	has emotions (26)
listens (14)	moves/acts (11)	has a mind (11)	has emotions (18)	can laugh (10)	is alive (14)
has ears (13)	makes music (9)	is strong willed (9)	can hear (17)	can be sad (10)	talks (8)
is solid (12)	is solid (9)	hears (7)	is solid (13)	talks (10)	eats (7)
has emotions (10)	is fictional (9)	talks (6)	empathizes (9)	can love (8)	hears (7)
understands (7)	has emotions (7)	is fictional (6)	has a mind (7)	is alive (8)	has a mind (6)
is hard (7)	has a mouth (6)	is alive (5)	is alive (5)	can hear (8)	is aware of surroundings (6)
is self-aware (6)	can hear (6)	is self-aware (5)	moves/acts (5)	is self-aware (8)	sees (5)
is alive (6)	is hard (5)	is human (5)	is hard (5)	has a mind (5)	is hard(5)

Table 3 The 10 most commonly mentioned features of various counterintuitive plant concepts.

Plant that				
can see	**can eat**	**has emotions**	**can talk**	**that sings**
grows (19)	grows (44)	thinks (22)	thinks (25)	talks (23)
eats (15)	drinks (14)	can cry (16)	can hear (17)	grows (20)
moves (15)	can digest (12)	can eat (13)	grows (13)	eats (14)
has eyes (13)	has roots (11)	can be happy (12)	has emotions (11)	is fictional (7)
thinks (13)	reproduces (10)	is alive (8)	can eat (11)	thinks (7)
has emotions (9)	has leaves (9)	is self-aware (8)	is alive (8)	breathes (7)
is self-awae (7)	can die (8)	can love (7)	has a mind (6)	has emotions (6)
is fictional (7)	poops (7)	has leaves (7)	breathes (6)	has roots (6)
reproduces (6)	talks (7)	can laugh (7)	is fictional (5)	can hear (5)
can hear (6)	has fruit (5)	can be sad (7)	has roots (5)	can dance (5)

Plant that			
can hear	**has strong beliefs**	**can understand**	**is self-aware**
can talk (23)	thinks (28)	talks (22)	thinks (25)
thinks (19)	grows (20)	thinks (19)	grows (19)
grows (16)	has emotions (15)	grows (19)	eats (18)
listens (13)	has roots (10)	has emotions (17)	has emotions (15)
has ears (11)	is self-aware (8)	can hear (14)	is self-aware (11)
can eat (11)	can eat (7)	is self-aware (7)	is alive (8)
has emotions (11)	has leaves (7)	is alive (6)	reproduces (7)
can see (7)	is alive (7)	empathizes with others (5)	has a mind (6)
is self-aware (6)	can talk (7)	has leaves (5)	is fictional (5)
is alive (5)	has a mind (6)	is green (5)	has leaves (5)

change as they find out about counterintuitive properties of an object. This is because counterintuitive properties activate concepts that are strongly connected to them in an agent's semantic memory. A "domain" in the context-based view thus is a set of propositions that are strongly connected in the agent's semantic memory and may or may not perfectly correspond to Barret's Table 1. Findings of our experiments hint at the strength of some of these connections. For instance, we can conclude that grows is strongly connected to eats because (1) our participants listed grows as a feature of the conceptual combination "rock that eats" whereas they had not included it as a feature of the category of rock alone, (2) the proportion of participants who listed grows as a property of "plant that grows" is larger than the proportion of participants that listed "grows" as a property of the category plant, and (3) our participant listed eats as a feature of the conceptual combination "rock that grows" whereas they had not included it as a feature of the category rock. Thus if a conceptual combination of a concept C with a property p causes a larger proportion of participants to include a feature f (than the proportion that had listed f as a feature of C alone), we consider it as an indication that p and f are strongly connected to each other in our participants semantic memories. Using this principle allows us to infer the two domains shown in Figure 4 and Figure 5.

Table 4 The 10 most commonly listed properties of counterintuitive persons.

The Person Who					
can walk thru walls	can see thru walls	can hear from miles away	can leap over skyscrapers	can fly	is invisible
is strong (27)	is strong (19)	can talk (16	is strong (35)	superhero (19)	thinks (13)
is a superhero (18)	is a super-hero (19)	thinks (14)	is a superhero (29)	can move (15)	rescues people (13)
has a mind (13)	thinks (15)	can fly (12)	can fly (16)	is a pilot (14)	is a super-hero (12)
thinks (13)	can fly (14)	is a superhero (11)	can move (13)	can eat (13)	is undetec-ted (11)
can fly (12)	can move (14)	rescues people (10)	has hand-s/feet (11)	has a mind 911)	is strong (11)
is a ghost (11)	rescues people (9)	is strong (9)	can eat (11)	thinks (9)	commits crimes (9)
eats (9)	is fictional (8)	has ears (9)	can see thru walls (9)	is strong (8)	is lonely (9)
has super-powers (9)	can talk (7)	can eat (9)	has a mind (7)	rescues people (8)	can fly (9)
can see thru walls (7)	can eat (7)	can learn secrets (7)	thinks (6)	can talk (7)	can walk thru walls (9)
can move (7)	has eyes (7)	has emotions (7)	rescues people (7)	is fictional (7)	can spy/hear secrets (8)

4 Experiment 3

The context-based view also suggests that as multiple counterintuitive properties from the same domain (e.g., grows, eats, and is alive) are added to a concept (e.g., rock) the new conceptual combination may indeed be so coherent that it may actually be less expectation violating than a concept with a single expectation violation. This study was designed to test this prediction. We created four high level categories of solid objects, living things, animals, and mental beings to correspond to Barrett's domains of physicality, biology, animacy, and mentality [6]. We selected the properties listed in Table 5 from expectation sets associated with these categories.

Each of the category labels was paired with one and two properties from a domain to create four types of statements:

1. **CE:** Category label + one intuitive expectation.
2. **CEE:** Category label + two intuitive expectations
3. **CC:** Category label + one counterintuitive expectation
4. **CCC:** Category label + two counterintuitive properties

The intuitive statements (CE & CEE) were created by pairing category labels with expectations from the category's associated expectation-set. Thus "all solid objects move as connected wholes" was one of the two CE statements created for the category solid objects. "Imagine 'a solid object that moves as a connected whole,' how likely is it that it also needs force to be moved?" was the only CEE statement created for the category of solid objects.

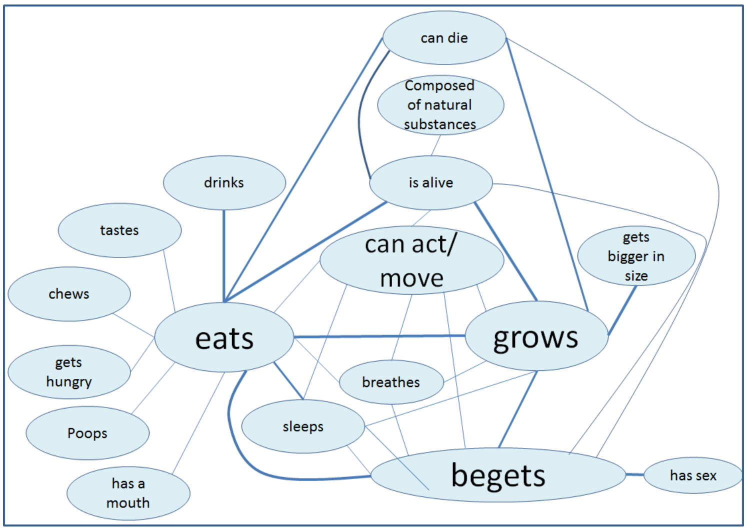

Figure 4 Context-based view of the biology domain.

As shown in Figure 6, the expectation sets can be organized hierarchically with physicality or solid objects on top and mentality or mental beings on the bottom such that objects belonging to lower categories inherit the properties of upper level expectation sets. Counterintuitive statements (CC & CCC) were created in two ways. For the categories of solid objects, living things, and animals, counterintuitive statements were designed by pairing an upper level concept (e.g., solid object) with a lower level property (e.g., grows). To create CC and CCC statements for the category of mental beings, we used the following six superhuman properties:

1. is invisible,
2. can fly through the air,
3. can see through walls,
4. can walk through walls,
5. can hear whispers from miles away, and
6. can leap over skyscrapers

4.1 Participants

Participants included 153 adult males and females from around the world who completed the online study through Mechanical Turk for a small remuneration. Three participants failed the attention check question (the question asked participants, "please do not click here") and thus were excluded from all subsequent analysis.

4.2 Materials and Procedures

The materials consisted of an online form that asked study participants to indicate their level of agreement/disagreement (on a 7-point Likert scale ranging from "3: Strongly agree" to "−3: Strongly disagree") with each of the 297 statements (13 CE, 10 CC, 65 CEE, and 209 CCC statements) constructed using the procedure described above.

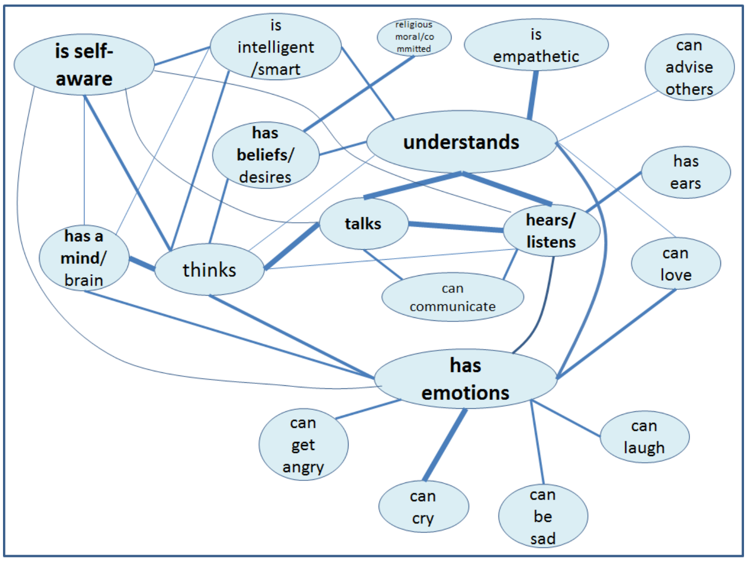

Figure 5 Context-based view of the mentality domain.

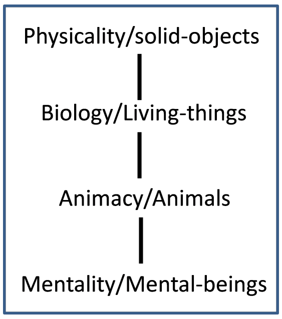

Figure 6 Expectation set hierarchy.

Table 5 Properties selected from expectation sets.

Solid objects	Living things	Animals	Mental Beings
1. move as connected wholes 2. physical contact is required for launching or changing the direction of movement	1. grow and develop over time 2. produce offspring that are similar to them 3. are composed of natural substances 4. have processes to satisfy their nourishment needs	1. take actions to satisfy their goals 2. are self-propelled	1. see through eyes 2. have self-awareness 3. have emotions 4. understand others 5. can talk to others 6. can hear others 7. have strong beliefs 8. can sing songs

Table 6 Mean participant agreement scores (& standard deviations) for various statement types.

Type	Solid Objects	Living Things	Animals	Mental beings	Total
CEE	1.66 (1.90)	2.47 (1.09)	2.40 (1.07)	2.18 (1.19)	2.20 (1.21)
CE	0.78 (2.05)	1.87 (1.33)	1.16 (1.65)	1.36 (1.70)	1.26 (1.71)
CCC	−0.08 (2.11)	0.06 (2.15)	0.37 (2.17)	0.32 (1.84)	0.05 (2.10)
CC	−2.41 (1.20)	−0.46 (2.03)	0.47 (1.86)	−2.80 (0.75)	−1.82 (1.93)

4.3 Results & Discussion

Table 6 shows the mean participant agreement scores for solid objects, living things, animals, and mental beings. The overall results show that our participants rated the intuitive statements involving two intuitive expectations as least surprising and counterintuitive statements with one expectation-violation were rated as most surprising. As predicted by the context-based model, participants rated statements involving two violations from the same expectation-set as significantly less surprising than statements with a single expectation violation ($F=1.18$, $p < 0.05$). This pattern was also observed for solid objects ($F=3.06$, $p < 0.05$), living things ($F=1.12$, $p < 0.05$), and mental beings ($F=6.03$, $p < 0.05$). The results for animals, however, did not follow this pattern with CCC ideas being rated as more surprising than CC ideas, although the differences did not reach the level of significance ($F=1.36$, $p=0.31$).

The results of our study clearly show that people's perceptions of unexpectedness do vary continuously. We also did not find a sharp boundary between INT and MCI concepts as some intuitive ideas were rated as less expected than some counterintuitive ideas. The following intuitive concepts were rated by our participants to be more surprising than the counterintuitive concepts given below (mean expectedness ratings are shown in parenthesis besides each statement).

- **More Surprising Intuitive Statements**
  1. Mental being that understands others can also talk to others (mean expectedness: 0.73)
  2. Physical contact is required for launching or changing the direction of movement of all solid objects (0.73)
  3. Solid objects move as connected wholes (0.73)
  4. Animals are self-propelled (0.97)
  5. Solid objects that requires physical contact for launching move as connected wholes (1.09)
- **Less Surprising Counterintuitive Statements**
  1. Animal that can talk can also understand English (2.11)
  2. A solid object that has processes to satisfy its nourishment needs is also composed of natural substances (1.83)
  3. A solid object that produces offspring that are similar to it also grows (1.83)
  4. An animal that has strong beliefs also has self-awareness (1.74).
  5. An animal that talks also has self-awareness (1.50)

There were also differences in participant's expectedness rating for different domains (shown in Tables 3-6). Two-property intuitive statements (CEE) involving living things were rated by participants as more expected than two-property intuitive statements involving the other three domains. On the other hand, counterintuitive statements with one-property (CC) involving mental beings were rated as more surprising than counterintuitive statements involving the domains of animals, living things, and solid objects.

For each of the domains we can also compare ratings for intuitive and counterintuitive statements derived using properties taken from various expectation sets. Considering the domain with the largest number of statements, namely, that of solid objects. We can compare counterintuitive statements involving properties taken from expectation sets of living things, animals, and mental beings. The results show that counterintuitive statements created by pairing solid objects with properties taken from the living things expectation sets are perceived to be the least surprising followed by concepts created by pairing solid objects with animal expectations. The counterintuitive statements involving properties taken from mental beings domain are rated as most surprising. These results mirror the domain hierarchy shown in Figure 6. The closer the expectation to solid objects in the expectation set hierarchy, the less surprising people found the concepts created by pairing the concept with expectation sets derived from those domains. These differences in expectation scores involving expectation derived from different domains can be made sense of by appealing to the context-based as well as the content-based view. The context-based view, however, also predicts that there may also be differences in people's expectations for various properties that have been placed by Barrett [6] in the same expectation-set. We find several notable differences in expectedness rating provided by our participants. Consider the expectation set of living things, we found that the statements involving "produce offspring that are similar to them" to be rated by our participants as significantly more surprising than the statement involving about "consists of natural substances." This was true for whether the statements were paired with the concept of "living things" or "solid objects." Similarly for the "mental beings" expectation-set, we found that statements involving the property of "see through its eyes" to be rated as less surprising than "can talk to others." This was true regardless of the concept these properties were paired with.

We also found some property pairings to be rated more intuitive by our participants than other property pairings. For instance, being able to see was not considered by our participants to be relevant to singing. Similarly, while talking, hearing, and understanding (and singing, believing, and having self-awareness to a lesser degree) seemed to go together in our participant's minds, as statements involving talking, hearing, and understanding (such as "a rock that talks to others can also understand others") were rated significantly more intuitive than statements about seeing and singing (e.g., "a rock that can see through its eyes can also sing") or seeing and talking/listening/understanding. In fact the statements about "solid objects" talking and listening, talking and understanding, and talking and being self-aware were rated as less surprising than intuitive statements that paired solid objects with expectations from the solid-object-expectation-set. This supports the prediction of the context-based model that certain multiple violations from the same intuitive expectation set may be perceived by people to be less surprising than single expectation violations.

The results of this study also shed some light on a yet mostly unexplored aspect of the context-based model, namely, the postdiction process of how people make sense of the surprising information. Upal [5, 12] argued that through cumulative effects of repeated postdiction (especially when such sense-making is culturally sanctioned) an initially counterintuitive concept may over time become intuitive for some individuals. Our results show that multiple expectation violations involving properties that are strongly connected in an agent's semantic memory (presumably because they frequently co-occur in an agent's information environment or because there are causal theories that links them together), make it easier for that agent to justify expectation violations and make the new concept coherent. Thus since talking, listening, and understanding are strongly connected in our participant's minds, mention of any one of these concepts strongly activates the other two unmentioned concepts. Thus upon hearing of a solid object that talks, our participants expect that solid object to also be able to talk and understand. This explains why co-occurrence of these properties is rated by our participants to be significantly more intuitive than co-occurrence of properties that are unrelated in our participant's minds (even though they are placed in the same intuitive expectation set by Barrett).

While the results of our study do indicate a need to revisit the particular contents of intuitive expectation sets as laid out by Barrett [6], they also illustrate the futility of the whole notion of creating fixed sets of cognitive universal intuitive expectation sets that exhaustively encode all expectations that all people have at all times! The context-based model avoids these ad-hoc boundaries by arguing that people's expectations for various concepts vary continuously and that memory for various concepts is a function of (a) how surprising people find a concept, and (b) people's ability to make sense of the concept once they have seen them.

5 Conclusion

The finding that counterintuitve concepts embedded in stories are more memorable than other types of concepts has been important for cognition and culture in general and cognitive science of religion in particular. Barrett [6] attempted to devise a coding scheme to allow clear identification of intuitive and counterintuitive concepts by hypothesizing six intuitive expectation domains. The studies reported here are the first empirical attempt to elicit people's intuitive knowledge about various common categories. Our results suggest a refinement of Barrett's of mentality and biology domains that should help cognitive scientists of religion and others make more precise predictions about memory for counterintuitive concepts. We also found that people find concepts that include multiple violations of closely associated features (such as talking and listening in case of "a rock that talks and listens") to be less surprising than concepts that violate only one of these expectations (such as a rock that talks).

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Finding Stories in 1,784,532 Events: Scaling Up Computational Models of Narrative*

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Abstract

Information professionals face the challenge of making sense of an ever increasing amount of information. Storylines can provide a useful way to present relevant information because they reveal explanatory relations between events. In this position paper, we present and discuss the four main challenges that make it difficult to get to these stories and our first ideas on how to start resolving them.

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Keywords and phrases big data, news, aggregation, story detection

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1 Introduction and Motivation

Every working day, millions of news articles are produced by thousands of different sources that report on many different events that happened, are happening, or may or will happen in the world. Some sources provide the same account, some complement each other, some provide different perspectives and some sources contradict each other. Information professionals are facing the challenge of making sense of this ever increasing information deluge [8].

A core task here is to create reconstructions of what happened where, when and to whom, to provide explanations of particular events or identify relevant actors. They can be seen as narratives or stories about the real world that need to be discovered in the data. We consider storylines the most compact and informative structures for representing the essence of large volumes of news data over longer periods of time summarising the changes reported in the news as sequences of events involving participants but also hinting at explanations and point to the forces at work.

In the NewsReader project,[1] we aim to support information professionals by automating the reconstruction of storylines from large amounts of news articles over longer periods of time. We are developing natural language processing technology to process daily news streams in four languages (English, Spanish, Italian and Dutch) to extract events and their arguments. Whilst we have a clear idea of how to represent this information as structured events, we are still investigating how to go beyond these events to automatically detect and represent storylines from literally tons of sources.

For most work on narrative analysis and modelling, the unit of the story is known e.g. a folk tale [11], novel [7], or film [4]. Identifying stories in large amounts of newspaper texts

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[1] http://www.newsreader-project.eu

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introduces several novel challenges. In this position paper, we outline the challenges that are involved when storylines are hidden in a large set of events coming from different sources.

This paper is organised as follows. In Section 2, we describe the global automotive industry use cases from the NewsReader project. In Section 3, we describe the four main challenges we have identified: scope, granularity, identity and change, and perspective. We summarise our main findings in Section 4.

2 Global automotive industry

The global automotive industry provides us with a case that is rich in complex and varied events, interactions between key players and possible storylines. For a first pilot, we have collected and processed 64,423 news articles from the LexisNexis archive[2] (out of their 6.1 million English available news articles about the car industry between 2003 and 2013). The processing consisted of a traditional natural language processing pipeline in which we first performed a structural analysis of each article (e.g. part-of-speech tagging, syntactic parsing) of the text followed by a semantic analysis (e.g. named entity recognition and linking, event detection and semantic-role-labeling, opinion mining) [1]. Then, mentions of events and entities are matched across the documents to establish coreference relations following [5], i.e. what accounts write about the same events. The coreference relations are used to aggregate information for uniquely defined instances of entities and events. This results in a reduction from 3,127,446 textual mentions of actors (for example persons or companies) to 445,286 instances. For locations, there is a reduction from 1,049,711 textual mentions to 62,255 instances and for events a reduction from 5,247,872 text mentions to 1,784,532 instances.

We know a host of interesting stories are to be found inside this collection of events, actors and locations. There is for example the story of the Porsche and Volkswagen take-over that describes Porsche buying an ever growing stake in Volkswagen between 2005 and 2009, prompting speculations that Porsche would take over Volkswagen. However, with the turn of the economy, Volkswagen reversed the tide in 2009 and eventually took over Porsche. Around this story, there are related stories revolving around the different actors related to these companies such as those of key staff members Wendelin Wiedeking and Ferdinand Piëch. These stories are only the tip of the iceberg. Through automatic detection of interesting stories we aim to discover new stories that were previously hidden in the data. The main challenges we encounter in identifying these stories are presented in Section 3.

3 Narrative Detection and Modelling at Scale

While each news article tells a story on its own, we aim to construct a story across different news articles that may be published over long timespans. We have identified four challenges that come into play when information comes from different sources which may not all be related: scope, granularity, identity and change, and perspectives.

3.1 Scope

When considering news articles around a certain time, we do not know a priori which stories are interesting or relevant to tell, who the relevant actors (characters) are in our domain and which events are relevant to include in the story. We thus need to determine the scope or

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[2] http://www.lexisnexis.com

extent of the story. As we have a continuous stream of incoming news articles, one of the things we also need to identify where a story begins and where it ends.

Most news aggregation systems[3] and story detection approaches from news streams such as [10] use some measure of frequency within a particular timeframe to assess the trendiness of a topic which may indicate its importance, as well as its rise and fall. While this may be a good measure for identifying the main events in popular stories, it is not suitable for identifying less popular stories. These techniques may thus not lead to novel insights but rather point to (parts of) stories that are most well-known.

Besides events and characters being mentioned frequently (the volume of the news), we are therefore also looking into detecting strong emotions and opinions (sentiment analysis), impact or involvement of a larger number of characters (local vs global reporting) and particular events types or actors that are valued (for example particular scenarios or, following [2], interesting or key characters in the domain).

Once the events around the climax of a story are identified, events that led up to the climax can be traced. Temporal and causal relations between events, involved actors, intentions and speculations (e.g. speculations on a take-over, a promise by a CEO) and critical changes of states (e.g. a series of take-overs eventually resulting in a company becoming a market leader) can be used to trace these events. We use our NLP analysis tools to detect relations, entities and events, together with domain knowledge to type events, identify motifs or scenarios and importance of events in a particular scenario. We can utilise coherence measures as proposed in [12] to ensure the selected events form a coherent story.

3.2 Granularity

As the goal of NewsReader is to support information specialists in reconstructing stories relevant to their domain, we interviewed some information specialists. We learnt from these interviews that their daily work includes high-level abstract cases as well as fine-grained detailed cases and everything in between. Our story model therefore needs to be able to detect and model both high and low level stories. Users may initially start with a higher level story, and then find that they need to zoom in on particular details. It is therefore important to be able to identify high-level stories such as the Volkswagen-Porsche take-over, but also its finer grained events (e.g. changes in the stock market), actors (e.g. persons involved in negotiations) and storylines (e.g. developments within Porsche) are part of a more general storyline.

Modelling hierarchical relations between entities that enable us to switch between for example corporate-level and person-level stories may be a first step towards addressing this challenge. Such hierarchies may also come in useful for the next challenge.

3.3 Identity and Change

News stories report on changes in the world. While events are identified as points of change, these often change the state of the actors involved too. In the car domain, actors merge or take over each other and some actors are thus absorbed. This happened for example to Daewoo, a South Korean car maker that has gone through several name changes since its founding in 1982. In 2001, General Motors took over Daewoo and in 2005, the names of all Daewoo car models were re-badged as Chrevrolet models in Europe, thus effectively making

[3] `http://emm.newsexplorer.eu/NewsExplorer/home/en/latest.html`

the name ‘Daewoo’ disappear on this continent. If one were to do a simple search on the database for events in which Daewoo was involved, the events would stop after 2005, but one could also argue that they continued under a different label.

Detecting and modelling the relationships between different actors through time is necessary to deal with this from a database querying perspective. From a storyline perspective, one needs to be able to express hierarchies of actors (for subsidiaries of different companies for example) as well as actor changes through time. We are investigating whether some advances made in the knowledge representation domain can be applied to NewsReader storylines. As a starting point we take [9] which presents a model for capturing entity changes over time.

3.4 Perspective

It is commonly accepted in the theory of narratology that there is a distinction between the story itself (the fabula) and way the story is told (discourse) [3]. News sources are not objective [13] as there are various reasons for a source to present an event in the way it does, or even to select an event for presentation.

As the NewsReader project analyses news articles from a large variety of sources (3,111 for the cars data), it is inevitable that some of these sources contradict each other. In a recent car recall case, one source states that 900,000 cars are recalled,[4] while another claims ‘only’ 644,000 cars are recalled.[5] We currently use a similarity measure between event descriptions to establish whether two sources are talking about the same event. This makes it particularly challenging to automatically detect when contradictory information points to different events and when contradictory information provides alternative perspectives.

However, we have developed a model to represent such information. Through the Grounded Annotation Framework [6],[6] we can store the source of each event mention. This allows us to compare how different sources talk about a specific event. We can look into the number of references to an event or amount of detail a specific source provides. However, in order to detect more subtle differences in perspectives, we will need to do a deep analysis of the text and look for example at stylistic differences such as word use and differences in focus of the article or level of detail given.

4 Conclusion

We presented the challenges encountered when one tries to identify stories in large amounts of data consisting of many units that may or may not be related to the same story. Our four main challenges related to this goal are: scope, granularity, identity and change, and perspectives. We presented our current research directions for identifying the scope of a story and referred to GAF which allows us to compare perspectives. Dealing with granularity, identity change and identifying alternative perspectives are still open challenges.

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Narratives as a Fundamental Component of Consciousness*

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Abstract

In this paper, we propose a conceptual architecture that models human (spatially-temporally-modally) cohesive narrative development using a computer representation of quale properties. Qualia are proposed to be the fundamental *cognitive* components humans use to generate cohesive narratives. The engineering approach is based on cognitively inspired technologies and incorporates the novel concept of quale representation for computation of primitive cognitive components of narrative. The ultimate objective of this research is to develop an architecture that emulates the human ability to generate cohesive narratives with incomplete or perturbated information.

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1 Introduction

Five decades of research in computational Artificial Intelligence (AI) have resulted in significant progress towards making our lives easier, safer and more interesting, but the state of AI technology is far from realizing the original vision that computers would by now be capable of *thinking* on par with humans over a broad range of subjects. For example, a computer model cannot reliably identify an enemy tank, isolate cancerous tissue in a mammogram or differentiate a computer virus from non-malicious code. Computer automated systems based on conventional approaches cannot account for situations that were not programmed in advance; a human is required to make a final determination. Humans can adapt to new situations and have the unique ability of 'gist' processing, which involves data compression for reasoning and making rational decisions in an environment of imprecision, incomplete information, uncertainty and partial truth [8, 3, 7]. We believe humans process information in terms of conscious narratives which allow us to generate a stable, consistent and useful representation of reality, hence, our interest in *advances in computational models of narrative*.

* The views expressed in this paper are those of the authors and do not reflect the official policy or position of the United States Air Force, the Department of Defense, or the US Government.

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This paper presents a computational architecture that emulates the human capability of identifying elements and solving problems with imprecise and incomplete information, interpreting stimuli qualitatively and operating with compressed data, or "gists" h[2].

Our contribution is two-fold. First, we propose to develop a computer representation that captures key *properties* of the fundamental cognitive component humans use to generate (spatially-temporally-modally) cohesive narratives, the quale (plural qualia).[1] Qualia are the primitive structures which provide cognitive imagery and emotions to narrative events. Clearly humans process information in a way that is different from traditional AI approaches, we therefore seek to model the properties of conscious experience which humans use to generate cohesive narratives.

Second, we propose an architecture designed to model narrative development and the process by which competing narratives are selected. The proposed architecture design consists of methodologies and technologies inspired by and designed to model human cognitive processes. This architecture consists of loosely-coupled layers, each implementing a unique function. The intended outcome is a framework that will overcome the problem of brittle AI systems and allow for a more robust and flexible architecture similar to the human ability to process with incomplete or perturbated information.

2 Overcoming Limitations of Current AI Approaches

Current AI approaches work in *data space*, aggregating large volumes of data to infer the general from the particular, i.e. inductive reasoning. Inductive systems are prone to be overly complicated, require a vast amount of data processing and cannot infer answers not previously programmed. Alternatively, humans reason in *event space*, by creating a cohesive narrative, a hypothetical explanation of observations. Narrative creation is an abductive process, an inference to a stable, consistent and useful explanation which accounts for goals and motivations. We posit that abductive reasoning, either alone or in conjunction with current AI approaches, will prove to be superior to current AI methods.

3 Computer Representation of Qualia Properties

Qualia are subjective, context-dependent internal representations of evoked experiences based on received or predicted sensor data [3]. Qualia provide the representation (mental-ease) through which all life forms generate a useful and consistent world model [8] and provide a cognitive structure to cohesive narratives. Our memories are not based on raw sensory input, but rather stored representations of qualia that were evoked by the sensory data, and we construct narratives based on the stored qualia [7]. This requires a method of manipulating qualia properties in memory and making sense out of the internal representation to represent the external world. Words in a human language are essentially labels used to communicate concepts which leads us to the potential of using Computing With Words (CWW) as a way to implement a qualia-property-based computational environment. CWW, which is based on fuzzy set theory and fuzzy logic, was developed to convert *concepts* from a cognitive format into a representation that could be processed computationally [16]. When humans lack full information they use narratives represented by words and propositional phrases to fill in the knowledge gap [9].

[1] Qualia are proposed as the fundamental *cognitive* component, not to be confused with proposed fundamental components of a narrative as proposed by Baikadi and Cardona-Rivers [1].

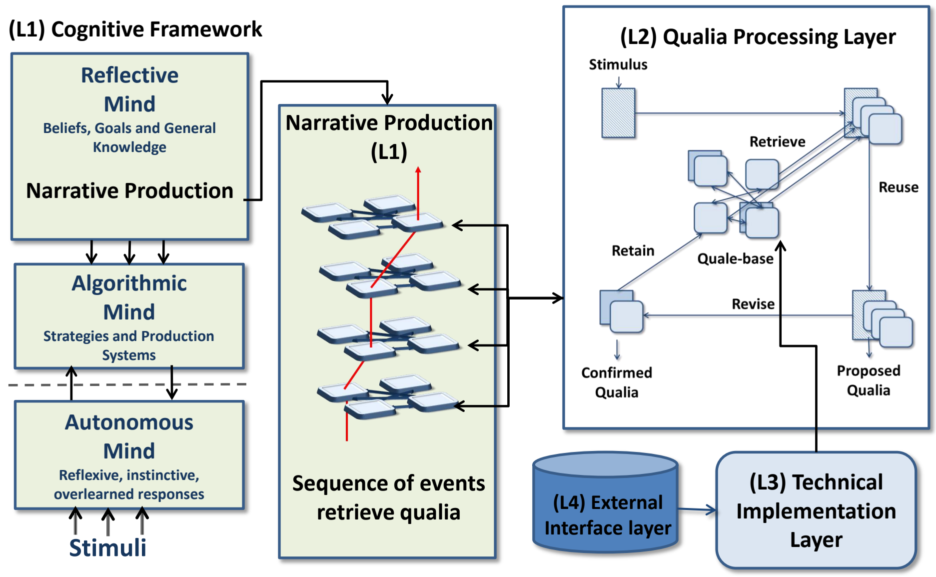

Figure 1 Cognitive Architecture [13, 14].

4 Architecture

The proposed architecture consists of four layers designed to emulate cognitive processes as shown in Figure 1. The highest layer of abstraction, L1, is a *framework* that implements the dual-process theory of higher cognition [13]. Narratives are generated within the *Reflective Mind*, one of three *minds* comprising the *framework*. Within the *reflective mind* we implement the *process layer*, L2, which stores, retrieves and updates the fundamental components internal to the framework used to create narratives. The *technical implementation* layer, L3, implements a technical solution for computer representation and calculations. An *external interface layer* (L4) connects to external entities and allows for the introduction of new concepts via a semantic network, such as ConceptNet, WordNet, and Lexipedia.

4.1 Cognitive Framework (L1)

The cognitive framework layer is based on the tripartite model of mind, which explains human cognition by the interaction of the three minds or cognitive levels [12, 13]:

- The *autonomous/reactive mind* is characterized by reactivity to external stimuli. Stimuli can be attended to reflexively, and can be passed to the reflective mind for conscious processing, at which point qualia are evoked.
- The *algorithmic mind* is responsible for cognitive control (sequencing behaviors and thoughts). Fluid intelligence is the general computational power of the algorithmic mind and is exemplified by the ability to sustain simulation and hypothetical thinking.
- The *reflective mind*, responsible for deliberative processing and rational behavior is characterized by sequentiality. It accesses general knowledge structures, personal opinions and beliefs and reflectively acquired goal structures; this is where spatially, temporally and modally cohesive narratives are generated. Qualia processing (L2) is one of many components of narrative development, and the component our research is addressing.

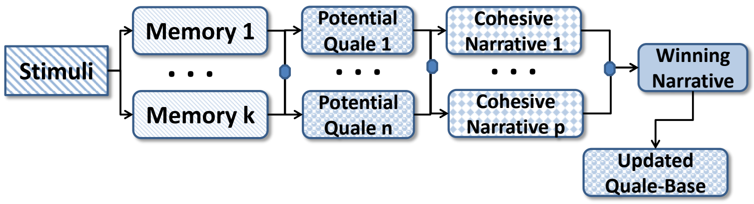

Figure 2 The Stimuli-Qualia Gap.

It is within the reflective mind that competing narratives are evaluated and the most plausible is selected. The methodologies required for this process are the primary areas of our research. Previous research [4, 5] describes an implementation of the tripartite model using agent based modeling techniques to simulate the processing of information within and across the three minds. We propose to extend this approach for our cognitive framework (L1).

4.2 Processing Layer (L2)

The *process layer* seeks to resolve the relationship between external stimuli and properties representing internally generated (evoked) qualia, known as the stimuli-qualia gap. We believe reasoning using quale-based representations will better emulate the human ability to perform gist processing. As shown in Figure 2, external stimuli generate memories that evoke qualia, which in turn generate one or more cohesive narratives (hypotheses). Humans select the most credible narrative and update their quale-base with new quale as appropriate. Case-based Reasoning (CBR) originated with research into how humans apply previously learned knowledge to new problems using previously solved situations [10, 15, 14]. CBR incorporates four activities in a continuous cycle of learning, or improvement [14]: retrieval of similar cases, reusing a solution suggested by a similar case, revising a solution to better fit a new problem, and retaining the new solution once it has been confirmed or validated.

4.3 Technical Implementation Layer (L3)

The technical implementation layer implements (in software) the generation, retrieval and processing of qualia properties to support cognitive simulation. It is within this layer that quale properties are processed using CWW as discussed earlier.

4.4 External Interface Layer (L4)

When the proposed architecture is initialized, it will have a starting knowledge base. Over time it will expand to new domains, and include new knowledge. To expand the knowledge base we propose the integration of external semantic networks, allowing the integration of new concepts and new stimuli-quale relationships. The initial semantic network being considered is ConceptNet, a crowdsourced database describing general, commonsense knowledge expressed in words. A concept is the fundamental unit represented, and concepts are related to one another [11, 6].

5 Conclusion and Future Work

This paper presented an approach for developing a cognitive architecture based on the novel concept of quale representation and modeling human cohesive narrative development. We posit the resulting implementation will lead to a methodology for improved decisions and greater Situational Awareness (SA).

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A Computational Narrative Analysis of Children-Parent Attachment Relationships*

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Abstract

Children narratives implicitly represent their experiences and emotions. The relationships infants establish with their environment will shape their relationships with others and the concept of themselves. In this context, the Attachment Story Completion Task (ASCT) contains a series of unfinished stories to project the self in relation to attachment. Unfinished story procedures present a dilemma which needs to be solved and a codification of the secure, secure/insecure or insecure attachment categories. This paper analyses a story-corpus to explain 3 to 6 year old children-parent attachment relationships. It is a computational approach to exploring attachment representational models in two unfinished story-lines: *The stolen bike* and *The present*. The resulting corpora contains 184 stories in one corpus and 170 stories in the other. The Latent Semantic Analysis (LSA) and Linguistic Inquiry and Word Count (LIWC) computational frameworks observe the emotions which children project. As a result, the computational analysis of the children mental representational model, in both corpora, have shown to be comparable to expert judgements in attachment categorization.

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1 Introduction

The way children view the world is based on the relationships established with their caretakers. Children perceive themselves according to the way they perceive their relationships with caretaker. But, how do we get to know the way children see themselves and the way they are perceived by others? Children-parent attachment relationships are reflected in their speech and attitudes. Children live in a fantasy world. Because of this, we can connect with their emotions through stories and narrative. These emotions are relevant because the understanding of the world developed in infancy will persist over time. Thus, the most

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popular methodology to explore children attachment relationships with their parents are unfinished stories [25].

Hence, the aim of this study is to explore and analyse attachment relationships on the basis of the representational models of attachment. The significance of attachment theory [2, 1], considered one of the most important theoretical and empirical constructions in the field of socio-emotional development, is based on the formulation of internal working models of oneself and one's relationships, in close connection with behaviours and feelings.

The internal working models reflect the construction of a mental representation of the world, based on the generalisation of the interactions children experience with their attachment figures during their early relations with the adults that satisfy their needs, and include the internalization of specific attributes and expectations of both their own behaviour (feeling loved, accepted and protected) and the behaviour of their attachment figures. They also constitute a pattern for the relationships that individuals will then establish throughout the rest of their lives [15].

During early childhood, as a result of new cognitive-representative, communicative, social and motor skills, children enter a new phase in the development of attachment, known as goal-corrected partnership. During this complex phase, changes which enable a greater diversity of behaviour occur. Thus, it has been observed that attachment behaviours are activated less frequently and with less intensity, since dyadic modulation patterns for ensuring emotional balance are well established; in other words, physical contact, while still necessary, gradually develops into psychological contact. The relationship is internalized and becomes representational. Children become more autonomous and emotionally self-regulating. The moral self emerges, reflected in child's ability to defer behaviour, abide by rules and correct their behaviour in the absence of the attachment figure. Nevertheless, the most significant aspect of this new phase is that members of the attachment pair begin to operate in accordance with a set of shared plans and objectives, thus fostering a closer, more intimate relationship which lays the ground-work for the development of more complex partner or social relations, which later extend to peer relations and relations with other significant adults [5, 28].

The mental model of the relationship is more elaborate and better adjusted to reality. Coupled with increased communicative skills, the cognitive changes that occur enable a more appropriate expression of demands, the communication of internal states and dialogue. Little by little, children begin to be able to infer the goals and understand the intentions, feelings and emotions of their attachment figure. These contents are all incorporated into this more complex structure, thus enabling children to operate internally both with their own perception and representation, and those of their attachment figure.

Based on the proposals forwarded by [2], other authors (e.g. [3, 4]) have made interesting contributions which have helped underscore the importance of the gradual emergence of models and their changes during early childhood. This is a particularly significant period for children's development and growth because it is during this time that certain components become consolidated as "scripts" or knowledge structures.

Attachment during early childhood has been studied very little. Today, however, it is the subject of several interesting investigations, and according to [2], there is still much to be discovered in this sphere. Focusing on these developmental attachment patterns and the contribution of parents may provide some guidelines for exploring this age range in more detail.

Affective states (attachment) of 3 to 6-year-old children can be evaluated by means of projective measures [30]. These tests are most adequate in the evaluation of affective states for this age range. Children express their feelings using the Attachment Story Completion Task (ASCT) [29]. Based on the story, children reflect the type of affective relationship.

However, the evaluation of the information by experts, despite the systematic detail description by [29], is difficult to measure and extremely time consuming. Therefore, the use of computational means for the comprehension of projective measures could be a beneficial application of computational language analysis for the detection of this psychological phenomena. But, is it possible? Can we model the required semantics for attachment representation? Is a computational analysis of semantic representation of children-parent attachment relationship possible? Are those implicit emotions sufficiently present in language to be detected by language representation models?

There are theories of language (embodied cognition) that argue that meaning can be captured only by grounding linguistic symbols (words) in the human body and its interaction with the environment. Other theories argue that meaning can be captured by their relation to other symbols (words) [16]. However, language has also been considered both symbolic and embodied, both processes converge and meaning is encoded in both featural and distributional information [16]. Hence, some authors suggest that the relevant information to extract semantic categories is coded redundantly on perceptual and linguistic experience. Thus, distributional models based on semantic knowledge are based on regularities or word co-occurrences. The more similar the contexts in which two words appear, the more similar their meaning. In contrast, feature-based semantic representation is a list of descriptive features which represent meaning [23].

Hence, context semantic representation of language based on word co-occurrence is modelled by Latent Semantic Analysis (LSA) [13], Hyperspace Analogue to Language (HAL) [17] or the Topic model [9]. This study takes a LSA approach to model the distributed semantics behind children-parent attachment relationship representation. Latent Semantic Analysis (LSA) is a statistical corpus-based natural language understanding technique. LSA has been widely used to model semantic similarity in a variety of contexts. Amongst others, LSA has been successful simulating text comprehension and text coherence [8]. LSA was developed by [6] and later found to be comparable to humans in similarity judgements by [13] and [14]. The first achievement was in information retrieval, where LSI gained an improvement between 10% and 30% in the capability to retrieve documents with equivalent meaning but with different words, TREC3 [7]. In addition, LSA has shown to be capable to deal with complex psychological phenomena such as metaphor [10] and predication [11]. Apart from being capable of gathering documents containing the same key-words, LSA is able to gather documents with semantically similar words to the key-word.

However, LSA does not take into account word-order, and does not take into account certain linguistic structures such as negation [12]. There are non semantic linguistic structures which are specifically relevant to secure versus insecure attachment categorization; therefore, alternative approaches should be explored. Thus, linguistic cues have also been gathered by means of the Linguistic Inquiry and Word Count (LIWC) [20, 27]; which has proved to be successful detecting meaningful measures in categories such as attentional focus, emotion and social relationships based on linguistic features [27]. In terms of semantics, LIWC produces linguistic indicators in a feature-based approach.

Thus, is it possible to analyze children-parent attachment experiences by computational means? Is it possible to discriminate between secure and insecure attachment by computational means? In order to address those questions, this paper is organised as follows. In Section 2, there is a description of the studied corpora and the studied attachment relationship categorization. Section 3 describes the different computational means used to analyze attachment emotions. Section 4 contains the data analysis and the results obtained in the studied corpora. Finally, Section 5 refers to final discussion and future work possibilities.

2 Children story corpora

The corpora was created based on stories collected in a previous study [22]. The sample selected comprised stories produced by 111 children (55 boys and 56 girls) from Irun (a town in the Basque Country, Spain), aged between 3 years 9 months and 6 years 3 months. All were in either the 2nd or 3rd year of preschool. All the children in the sample were from intact two-parent families and had lived with both their parents from birth. Parents' consent was requested and received before the trials were administered.

The "Attachment Story Completion Task" (ASCT) [29] was used in this study. The aim of this instrument is to assess participants' mental representation of themselves in relation to attachment to parents and the pattern of communication established in children aged 3 to 6. The most important difference between this measure and classification systems known as "Doll Play" [19] is that in this one, both the father and the mother are main characters in the stories, thus enabling attachment styles to be assessed individually for each parent.

The ASCT procedure consist of a series of story stems (*The stolen bike, The present, I'm sorry, A fight at school* and *A monster in the bedroom*) which are presented and narrated by the researcher using a set of dolls which represent a family in different circumstances. In this paper, the collected stories are about *The stolen bike* and *The present.*

2.1 Corpus one (*The stolen bike*)

The collected stories are about *The stolen bike* (see Figure 1): A teenager he/she does not know steals the bicycle that the child's parents have given him/her (the story represents fear or a external threat). The child is asked to complete the story. Stories feature the father or the mother separately, and are presented in a counterbalanced order. The story has its theme and situation designed to activate attachment.

Some of the initially collected stories were not included in this corpus due to cross-linguistic issues. In some stories some or most of the speech was produced in Basque language and this combination made computation more complex. All the stories were kept in the same language. The resulting corpus is composed of 184 stories (each participant produced a story for each of the parents) and a total of 24550 words: 12061 words are dedicated to father stories and 12492 words to mother stories. Finally, in addition to verbal information, there were expert judgements associated to all the stories [22], where the story attachment levels were categorised and rated using the "Attachment Story Completion Task" [29] coding.

2.2 Corpus two (*The present*)

The story is about *"The present"* (see Figure 2): Upon arriving home from school, the child gives his/her parents a present that he/she made for them (a positive emotional interaction between the child/parent pair, based on a positive social signal emitted by the child).

In the same way as in corpus one, some of the initially collected stories were not included in the corpus. Some for the same cross-linguistic effect and a few due to a technical issue. The resulting corpus is composed of 170 stories (each participant produced a story for each of the parents) and a total of 18071 words: 8757 words are dedicated to father stories, while 9314 words are dedicated to mother stories. In the same way as in corpus one in there were expert judgements associated for all the stories.

Figure 1 Set of dolls representing a family in *"The stolen bike"*.

2.3 Attachment relationship categories:

Each story ending given by participants is categorised as secure, secure/insecure or insecure and has its own scoring criteria, which are outlined below:

2.3.1 Secure response:

A secure response (4 or 5 points) is scored on the basis of the helpfulness, swiftness and responsiveness of parents' spontaneous response, happy ending to the story, any mention of positive sensations and a positive interaction between the parent/ child pair (care, consolation, assurance that the child is still loved, etc.).

2.3.2 Secure-insecure response:

A secure-insecure response (3 points) is scored on the basis of: not asking for help, absence of active engagement by parents, mention of only negative sensations (anger, physical punishment, etc.), feeling of not being loved, not feeling responsible for their actions, etc.

2.3.3 Insecure response:

A insecure response (1 or 2 points) is when there is no interaction between the parent/child pair or when said interaction is negative.

Figure 2 Set of dolls representing a family in *"the present"*.

In ASCT [29] authors suggest that the secure-insecure category needs to be defined to either the secure or the insecure option. Because of this, for data analysis only secure and insecure discrimination will be studied.

3 Computational Analysis of the Narratives involved in the ASCT stories

The analysis of the security emotions exhibited by children in narratives are analysed computationally by means of Latent Semantic Analysis, Linguistic Inquiry Word Count and programs to detect pauses and response eliciting questions.

3.1 Latent Semantic Analysis

LSA bases its knowledge on a corpus where LSA learns word similarities. Next, the vector representation of each word is measured statistically, based on the occurrence of words in the corpus. Finally, the cosine between vectors, measures text to text similarity.

First, we need a corpus which represents the desired semantic knowledge. Next, we will need to be able to measure similarity under the most adequate dimensions for our study. Similarity measures can be computed based on word to word, word to document or document to document comparisons.

3.1.1 Terms

LSA does not learn every word contained in a corpus. Only those terms whose meaning can be learned from context will be understood through LSA. The words understood by LSA are terms [6]. However, what condition should a word have to be considered a term? It should have a minimum amount of characters (default 2), it needs to appear in a document a minimum amount of times (default 1) and it should appear at least in a minimum amount of documents (default 2).

3.1.2 Documents

Every portion of text contained between two blank lines or a file will be considered a document. It will normally be a paragraph, although, if any portion of text (sentences, words, etc.) is contained between two blank lines in every case will be considered a document.

LSA considers the contexts of each term documents in which terms are contained. Therefore, documents selected in the text should be semantically sound.

3.1.3 Dimensions

The dimension ratios tend to be in the range between 50 and 1500 dimensions. Although the closest ratios to human measures tend to be between 100 and 400 dimensions [31]. Nevertheless, the most adequate dimensionality is typically chosen observing how close the similarity measures are under the different dimensions to human decisions.

3.1.4 Weight

In terms of weight, although we have the possibility to choose between three local and three global weights, LSA tends to use $\mathbf{log}(i,j)$ as a local value and $\mathbf{entropy}(i)$ as a global value [14].

LSA considers term weight: local and global. The **local weight** $L(i,j)$ measures the relevance of the i term in the j document and the $G(i)$, **global weight** looks at the relevance of the i term in the whole corpus. Every document has the same level of relevance.

LSA allows three main modes to compute local and global weights:

Local weights can be measured as

1. **tf**: *term frequency*: $L(i,j) = \mathbf{tf}(i,j) = m_{ij}$. It reflects how many times the i term appears in the j document. It is precisely what the source $\mathbf{M}$ matrix measures. Therefore using this method does not make any local change over the source matrix. The greater the frequency of a term in a document, the higher the weight it will have locally.
2. **log**: $L(i,j) = \mathbf{log}(i,j) = log(m_{ij} + 1)$. The *log* function makes it possible to reduce the difference between frequencies. Then, when writing its logarithm, instead of the frequency values, matrix values become a little more uniform in the distribution.
3. **bin**: $L(i,j) = \mathbf{bin}(i,j) = \min\{m_{ij}, 1\}$. This local measure eliminates frequencies from the m_{ij} matrix, replacing them with binary values. Therefore, if the i value appears at least once in the j document, a 1 value will be added. If the term does not appear, a 0 value will be added.

Global weights can be measured as

1. **none**: $G(i) = \mathbf{none}(i) = 1$. This global weight is constant, therefore the same for every term in the corpus. It aims to give the same relevance to every term in the corpus. When selecting $\mathbf{tf}(i,j)$ as a local value and $\mathbf{none}(i)$ as the global value, the $\mathbf{M}$ source matrix is left in its original configuration.
2. **normal**: $G(i) = \mathbf{normal}(i) = \frac{1}{||\mathbf{t}_i||} = \frac{1}{\sqrt{\sum_{j=1}^{n} m_{ij}^2}}$. When applying $t_1, \cdots, t_m$ weight to the terms, all the term vectors are normalised, thus all the vectors have the same length.
3. **idf** or "Inverse Document Frequency": $G(i) = \mathbf{idf}(i) = \frac{gf(i)}{df(i)}$, where $gf(i)$: "global frequency" measures the term appearance in the whole corpus. And $df(i)$: "document frequency" looks at how many documents contain each term.

$$df(i) = \sum_{j=1}^{n} \min\{m_{ij}, 1\}$$

4. **entropy**:

$$G(i) = \mathbf{entropy}(i) = -\sum_{j=1}^{n} p_{ij}\ log_2(p_{ij}), \quad \text{where} \quad p_{ij} = \frac{m_{ij}}{gf(i)}$$

Measures the lack of balance between terms and documents. The more balance in the frequencies, the higher the entropy.

3.1.5 Similarity measures

Similarity measures are calculated computing the cosine between the two vectors representing the semantic context [6, 13]. Cosine is the similarity measure which is closest to humans in semantic decisions made in vector semantic models. However, other similarity measures are available and have sometimes been tested for similarity purposes, e.g. dot product.

3.1.5.1 Similarity measures in *The Stolen bike*

Critical keywords for *The stolen bike* story were selected considering ASCT [29] coding and the story-based corpus lexicon. In order to gather this lexicon, the corpus was divided into two halves, secure and insecure stories. Both were tokenised and the most frequent story related content-words were selected as security representative keywords. The most frequent insecure tokens were mainly function words and were not very representative of insecurity for this specific story context. Therefore, in *The stolen bike* story-line, non-semantic approaches were found to be more informative for the detection of insecure story-lines.

In *The stolen bike* story, the *help seeking to the parents* was representative of secure narratives. In case the bike was not there, the parents would *help look for the bike until it was found*. Once the bike was found, the parents would assertively ask the robber to *get off the bike*. Often, secure stories would end up *recovering the bike* with a happy ending. Then, secure content keywords such as *bajar, quita (get off), da (gives), buscar (search), encontrar (find), recuperar (recover)* were selected.

Finally, all those term vectors and term combination vectors would be compared to the different stories to obtain similarity measures (cos) between the keywords and each of the stories.

3.1.5.2 Similarity measures in *The present*

The main keywords for *The present* were also selected considering ASCT [29] coding and the story-based corpus lexicon. In order to gather this lexicon, for the hand-coding procedure the corpus was divided into two halves, secure and insecure stories and the most frequent story related content-words were selected. For *the present* story-line, both secure and insecure speech keywords were selected.

A present, both to the eyes of children and parents in the story [29], can be *pretty* or *special* representing positive emotions, or can be *unattractive, uninteresting, useless* or *not good enough*.

Therefore, keywords were labeled as indicators of secure attachment –bonito (pretty), bien (well), contenta/o (happy), gracias (thank you), gusta (like), beso (kiss), abrazo (hug), jugando (playing), bueno (good), etc.

The same procedure was followed to select keywords for insecure attachment. In this case, indicators of insecure attachment such as mal (bad), triste (sad), enfadado/a (angry), castiga (punish), rompe (breaks), feo (ugly) or guardar (hide) were selected.

3.2 Linguistic Inquiry and Word Count

Linguistic Inquiry and Word Count (LIWC) is a text analysis program that counts psychologically meaningful words. Emotionally relevant features are computed in comparison to relevant dictionaries (word-lists). LIWC is able to detect meaningful measures in categories such as attentional focus, emotion, social relationships, thinking styles, and individual differences [27, 20].

LIWC contains word collections for each category. The studied categories are: Linguistic processes, psychological processes, cognitive processes and personal concerns. Those categories contain approximately 80 indicative measures for each psychological phenomenon [27]. Emotions can been detected by means of the identification of emotional features present in language. For example, deceptive language [18] or depression [26].

LIWC measures emotion indicators which are very relevant for the secure versus insecure attachment categorization. The length of the story can be an indicative characteristic of a secure versus an insecure emotional attachment relationship. A long story could mean a lot of explaining and tends to be related to insecure attachment relationships, while secure attachment relationship tend to be represented by a short story with clear facts [29]. Therefore, narrative length (WC) might be representative or indicative of the security level in the attachment relation. However, longer sentences and clear statements have been found to reflect a more complex secure relationship [29]. Sentence length will be represented in (WPS) and is indicative of complex sentences and a greater cognitive complexity [27]. Negative statements (negate) such as *I don't know* are common in an insecure attachment story-line [29]. Finally, negative emotional interaction, aggression and a bad ending (negemo, affect) are indicative of an insecure emotional attachment relationship[29]. These are five LIWC measures which seem to be very related to the ASCT coding and *The stolen bike* story-line. In addition, in the ASCT *The present* story coding positive emotions (posemo) are coded as indicative of a secure relationship. In the same way the absence of negative emotions (negemo) is indicative of a secure relationship. A summary of these measures is listed in Table 1.

Table 1 Selected LIWC measures.

LIWC2007	Description	Dictionary examples
Word count (WC)	Narrative length	–
Words per sentence (WPS)	Cognitive complexity	–
Negation (negate)	Inhibition	*No, not, never*
Affective processes (affect)	Emotional narratives	*Happy, cried, abandon*
Positive emotions (posemo)	Positive emotional narratives	*Love, nice, sweet*
Negative emotions (negemo)	Negative emotional narratives	*Hurt, ugly, nasty*

3.3 Computational Analysis of Pauses and Response Eliciting Questions

Pauses are common during narratives and the flow of the story is recovered by posing questions to redirect attention to the story.

3.3.1 Pauses

Pauses are considered in speech in terms of cognitive processing, affective-state, and social interaction [24]. Pauses, far from being empty of meaning, gather a great amount of information that needs to be considered. In the context of the "Attachment Story Completion Task" [29], the pause is a latency produced by the effect of the stimulus story-context in the narrative response of the child. Therefore, long pauses will have an affective nature and its length is most likely to be related to insecure affective relationships.

None of the previous resources take pauses into consideration, therefore a program was developed ad hoc to measure the presence of pauses in the narrative speech of children.

3.3.2 Response Eliciting Questions (REQ)

In addition to the previously described pauses, another important linguistic cue is questions. Once the pauses break the narrative flow or if the attention is directed to unrelated matters, posing Response Eliciting Questions (REQ) is required in the context of the "Attachment Story Completion Task" [29] to encourage the narrative process. In *The stolen bike* story, the need for more specific response eliciting questions is representative of insecure attachment relationships [29].

None of the previous resources take REQ into consideration, therefore a programs was developed ad hoc to measure the presence of those questions in children narrative speech interaction.

4 Attachment Security Detection

Computational analysis of semantic indicators, linguistic cues and pauses were compared to ASCT coded judgements to observe whether the measures were significantly related and if these indicators were capable of significantly discriminating between secure and insecure attachment.

Table 2 LSA Semantic Indicator Relatedness to Expert Measures in *The stolen bike*.

LSA Term Vector	Spearman's ρ	Significance
Baja / Baje / Recupera /Recuperado / Recuperan (Get off / Recover)	0.38	$p < 0.01$
Baja / Recuperan (Get off / Recover)	0.36	$p < 0.01$
Baja / Baje (Get /got off)	0.29	$p < 0.01$
Baja / (get off)	0.31	$p < 0.01$
Recupera / Recuperado / Recuperan (Recover / Recovered)	0.33	$p < 0.01$
Recuperan (Recover)	0.22	$p < 0.01$

4.1 LSA vector representation of Semantic Attachment Security

LSA semantic spaces were created for both corpora and the resulting semantic representations were analysed separately for each story context.

4.1.1 Corpus one: *The stolen bike*

In *The stolen bike* story expressions such as *"baja / baje de la bicileta"* (*"get/got off the bike"*) or *"recupero / recupera / recuperan la bicileta"* (*"recover / recovered the bike"*) are representative of secure attachment. Vectors of content-words such as *bajar, quita (get off), da (gives), buscar (search), encontrar (find), recuperar (recover)* were selected and the combination of vectors were selected as detectors. Those vectors were compared to the different stories to observe whether the resulting similarity measures (cos) between the vectors and each of the stories were related to security coding (see Table 2).

All the measures show significant relatedness to secure attachment expressions. However, it is clear that the first vector, *" baja / baje / recupera / recuperado / recuperan (Get - got off / recover / recovered)"* is best related to the expert coding. Therefore, this vector will be selected as the most salient semantic detector.

Next, we will observe if there are differences between security categories. A Kruskal-Wallis test shows that there are significant differences in terms of the studied three categories (secure, secure-insecure and insecure), $H(3) = 14.13$ and $p < 0.05$. Post hoc test using Man Whitney shows that there are significant differences between secure and insecure attachment measures, $U = 1988$; $p < 0.01$ and Cohen's $d = 0.54$.

4.1.2 Corpus two: *The present*

In *The present* there were indicators for both security and insecurity.

Representative of **security** were keywords such as bonito (pretty), bien (well), contenta/o (happy), gracias (thank you), gusta (like), beso (kiss), abrazo (hug), jugando (playing), bueno (good), etc. However, only *contenta* or the combined *contenta, contentos, contento* vectors produced significant associations (see Table 3).

Table 3 LSA Security Indicator Relatedness to Expert Measures in *The present*.

LSA Term Vector	Spearman's ρ	Significance
Contenta (Happy - she case)	0.19	$p < 0.05$
Contenta / contento / contentos (Happy - she/he/we cases)	0.24	$p < 0.01$

Table 4 LSA Insecurity Indicator Relatedness to Expert Measures in *The present*.

LSA Term Vector	Spearman's ρ	Significance
Castiga (Punish)	−0.2	$p < 0.01$
Enfadado (Angry)	−0.17	$p < 0.05$
Mal (Bad)	−0.15	$p < 0.05$
Castiga / enfadado / mal (Punish / angry / bad)	−0.17	$p < 0.05$

Thus, secure attachment is best represented by *" Contenta/o-s (Happy)"*, $\rho = 0.24$ and $p < 0.01$. A Kruskal-Wallis test shows that as security indicator significantly differentiates in terms of the studied three categories (secure, secure-insecure and insecure), $H(3) = 12.65$ and $p < 0.01$. Post hoc test using Man Whitney shows that there are significant differences between secure and insecure attachment measures, $U = 1512$; $p < 0.01$ and Cohen's $d = 0.71$.

Representative of **insecurity** were mal (bad), triste (sad), enfadado/a (angry), castiga (punish), rompe (breaks), feo (ugly) or guardar (hide). *" Castiga (Punish)", " Enfadado (Angry), Mal (Bad)"* or the combined vectors *" Castiga / enfadado / mal (Punish / angry / bad)"* offer significant associations to expert judgments (see Table 4).

Nevertheless, none of the insecurity indicators produce significant differences in secure, secure/insecure or insecure category discrimination.

4.2 LIWC indicators

In addition to distributed semantic indicators, there are other lexical and linguistic cues which are relevant as attachment security indicators: (1) the length of the story (WC), (2) the length of the sentence (WPS), (3) negation (negate), affective expressions (affect), positive emotions (posemo) and negative emotions (negemo).

4.2.1 Corpus one: *The stolen bike*

The indicators were compared to expert judgments to analyse which of them are most related (see Table 5).

All the indicators except posemo show significant relatedness to attachment expressions. Positive emotion was not significant, which is expected in the *The stolen bike* story line because it is created to evoke an external threat. Therefore, most of the selected LIWC 2007 indicators are representative of insecure attachment. For instance, negation is a good indicator for insecure attachment ($\rho = -0.51$ and $p < 0.01$). A high amount of negation implies a low attachment security measure (or insecure attachment). In addition, the presence of negative emotion expressions ($\rho = -0.37$ and $p < 0.01$), affective lexicon ($\rho = -0.2$ and $p < 0.01$) and the length of the story ($\rho = -0.2$ and $p < 0.01$) are also representative of

Table 5 LIWC2007 Indicator Relatedness to Expert Measures in *The stolen bike*.

LIWC2007	Spearman's ρ	Significance
WC	-0.2	$p < 0.01$
WPS	0.42	$p < 0.01$
negate	-0.51	$p < 0.01$
affect	-0.2	$p < 0.01$
negemo	-0.37	$p < 0.01$

insecure attachment. The higher the amount of negative emotion expressions, affective lexicon and longer stories, the more insecure the attachment measure is.

However, one of the LIWC 2007 indicators, sentence length (WPS), is well associated to secure attachment ($\rho = 0.42$ and $p < 0.01$). Long sentences are related to secure attachment.

All the LIWC 2007 indicators were tested but only those ASCT related measures showed to be significantly related.

Attachment security was significantly different across the studied narrative representations. Kruskal-Wallis test shows that there are significant differences for length of narratives, $H(3) = 2.77$ and $p < 0.05$ and post hoc test using Man Whitney show that there are significant differences between the secure and the insecure category, $U = 2254$; $p < 0.01$ and Cohen's $d = 0.42$. The cognitive complexity (WPS) also shows differences in terms of the three security categories, $H(3) = 30.56$ and $p < 0.05$ and post hoc test reflect significant differences between the secure and the insecure category, $U = 1477$; $p < 0.01$ and Cohen's $d = 0.84$. The same was tested for the inhibition (negate) represented in negative expressions, $H(3) = 14.36$ and $p < 0.05$ with post hoc significant differences between the secure and the insecure category, $U = 1647.5$; $p < 0.01$ and Cohen's $d = 0.92$. Another significant difference was found for emotional narratives (affect) $H(3) = 8.6$ and $p < 0.05$ with post hoc significant differences between the secure and the insecure category, $U = 2169.5$; $p < 0.01$ and Cohen's $d = 0.5$. Finally, significant differences were detected in terms of negative emotion expressions (negemo) $H(3) = 24.87$ and $p < 0.05$ with post hoc significant differences between the secure and the insecure category, $U = 1906.5$; $p < 0.01$ and Cohen's $d = 0.78$.

Consequently, all the studied LIWC measures were capable of producing security discrimination for ASCT coding.

4.2.2 Corpus two: *The present*

The indicators were compared to expert judgments to analyse which of them are most related (see Table 6).

Narrative length (WC) ($\rho = -0.47$ and $p < 0.01$), negation ($\rho = -0.24$ and $p < 0.01$) and positive emotion ($\rho = -0.15$ and $p = 0.04$) show association with expert judgements, whilst sentence length (WPS), affective expressions and negative emotion do not show to be associated. In the same way as in corpus one, short stories are representative of a secure attachment relationship. Similarly negative statements are associated with insecure relationships.

The same procedure was applied to observe if the studied indicators were capable of discriminating between attachment security categories. Kruskal-Wallis test shows that there are significant differences for length of narratives, $H(3) = 35.33$ and $p < 0.01$ and post hoc test using Man Whitney shows that there are significant differences between the secure and

Table 6 LIWC2007 Indicator Relatedness to Expert Measures in *The present*.

LIWC2007	Spearman's ρ	Significance
WC	-0.47	$p < 0.01$
WPS	0.11	$p = 0.13$
negate	-0.24	$p < 0.01$
affect	0.14	$p = 0.55$
posemo	0.15	$p = 0.04$
negemo	-0.11	$p = 0.1$

Table 7 Pauses and Response Eliciting Questions (REQ) in *The stolen bike*.

Indicators	Spearman's ρ	Significance
REQ	-0.47	$p < 0.01$
Pauses	-0.49	$p < 0.01$

the insecure category, $U = 1005.5$; $p < 0.01$ and Cohen's $d = 0.94$. The cognitive complexity (WPS) did not show differences in terms of the three security categories, $H(3) = 5.17$ and $p = 0.07$. The same was tested for the inhibition (negate) represented in negative expressions, $H(3) = 16.36$ and $p < 0.01$ with post hoc significant differences between the secure and the insecure category, $U = 1390.5$; $p < 0.01$ and Cohen's $d = 0.83$. There were also significant differences in the case of emotional narratives (affect) $H(3) = 11.46$ and $p < 0.01$ with post hoc significant differences between the secure and the insecure category, $U = 1744.5$; $p = 0.03$ and Cohen's $d = 0.41$. There were not significant differences in terms of negative emotion expressions (negemo) $H(3) = 5.8$ and $p = 0.055$. However, positive emotion expressions (posemo) did show capability of significantly detecting attachment security differences $H(3) = 12.96$ and $p < 0.01$ with post hoc significant differences between the secure and the insecure category, $U = 1704$; $p = 0.02$ and Cohen's $d = 0.44$.

4.3 Computational Analysis of Pauses and Response Eliciting Questions

In addition to the observed indicators, there are other narrative processes which are relevant as attachment security indicators: such as pauses (see Section 3.3.1) and response eliciting questions (see Section 3.3.2). Two programs were developed ad hoc to measure the presence of pauses and Response Eliciting Questions (REQ) produced by the expert to encourage the narrative process.

4.3.1 Corpus one: *The stolen bike*

Both indicators were compared to expert judgments to analyse which of them are most related (see Table 7).

Both narrative measures, pauses and response eliciting questions, are significantly related to attachment security representation ($\rho = -0.49$; $p < 0.01$ and $\rho = -0.47$; $p < 0.01$). The higher the amount of pauses and questions, the higher the tendency to insecurity.

Both measures detect significant differences across the studied narrative representations.

Table 8 Pauses and Response Eliciting Questions (REQ) in *The present*.

Indicators	Spearman's ρ	Significance
REQ	-0.56	$p < 0.01$
Pauses	-0.45	$p < 0.01$

Kruskal-Wallis test shows that there are significant differences for pauses, $H(3) = 33.66$ and $p < 0.05$ and post hoc test using Man Whitney shows that there are significant differences between the secure and the insecure category, $U = 1489.5$; $p < 0.01$ and Cohen's $d = 0.6$. There are also significant differences produced by the REQ, $H(3) = 33.67$ and $p < 0.05$ and post hoc test using Man Whitney shows that there are significant differences between the secure and the insecure category, $U = 1368$; $p < 0.01$ and Cohen's $d = 0.8$.

4.3.2 Corpus two: *The present*

Both indicators were compared to expert judgments to analyse which of them is most related (see Table 8).

Both narrative measures, pauses and response eliciting questions, are significantly related to attachment security representation ($\rho = -0.45$; $p < 0.01$ and $\rho = -0.56$; $p < 0.01$). The higher the amount of pauses and questions, the higher the tendency to insecurity.

Both measures detect significant differences across the studied narrative representations. Kruskal-Wallis test shows that there are significant differences for pauses, $H(3) = 30.78$ and $p < 0.01$ and post hoc test using Man Whitney show that there are significant differences between the secure and the insecure category, $U = 1019.5$; $p < 0.01$ and Cohen's $d = 0.64$. There are also significant differences produced by the REQ, $H(3) = 47.69$ and $p < 0.01$ and post hoc test using Man Whitney shows that there are significant differences between the secure and the insecure category, $U = 775.5$; $p < 0.01$ and Cohen's $d = 1.25$.

4.4 Comparison of the effect sizes obtained in the studied corpora

In conclusion, the LSA semantic vector, Word Count (WC), Words per Sentence (WPS), negation (negate), affective processes (affect), positive emotions (posemo), negative emotions (negemo), pauses and Response Eliciting Questions (REQ) are computational indicators of the level of the children-parent attachments security observed in narratives. These indicators have been compared to two corpora of unfinished children stories produced to elicit different emotions. *The Stolen Bike* was produced to evoke an external threat, whilst *The Present* was created to elicit a potentially positive emotional interaction between parents and children. Effect sizes in security vs. insecurity discrimination can be observed in Table 9.

5 Discussion

The aim of this paper has been to analyse whether the exploration of 3 to 6-year-old children-parent attachment representation through unfinished stories was feasible by computational means. The current study was run with a sample of 184 stories in *The Stolen Bike* corpus and 170 stories in *The Present*, which are a larger sample than most of the previous studies in this specific theme. Both story lines elicit different affective states: an external threat in the case of the *The Stolen Bike* and a positive interaction in *The Present*.

Table 9 Effect Sizes (Cohen's d) for the Computational Indicators of Children-parent Attachment Relationships.

Indicator	*The Stolen Bike*	*The Present*
LSA vector	0.54	0.71
WC	0.42	0.94
WPS	0.84	0.33
negate	0.92	0.83
affect	0.5	0.41
negemo	0.78	0.27
posemo	–	0.44
REQ	0.8	1.25
Pauses	0.6	0.64

The studied computational frameworks were capable of producing significant associations in relation to expert ASCT judgements.

LSA was capable of capturing the semantics behind secure affective expressions for both corpora. LSA significantly discriminates secure and insecure stories producing a medium effect size in *The Stolen Bike* (Cohen's $d = 0.54$) and in *The Present* (Cohen's $d = 0.71$). Therefore, once ASCT coding is considered, LSA produced consistent medium effect sizes in different corpora.

LIWC was also capable of capturing the linguistic cues which reflect secure and insecure affective expressions. However, there were differences in the two stories. In *The Stolen Bike* the story length (WC), sentence length (WPS), negative expressions (negate), affective expressions (affect) and negative emotions (negemo) were associated with human judgments. But in *The Present* only story length (WC), negative expressions (negate) and positive emotions (posemo) were related to expert judgments. The fact of negative emotion (negemo) being indicative only in *The Stolen Bike* and positive emotion being indicative only in *The Present* is due to the different affective states elicited by each story type. An external threat in the case of *The Stolen Bike* and a positive interaction in *The Present*. Hence, *The Present* involves a positive and quality interaction, while in *The Stolen Bike* negative emotions are maximised.

LIWC was also able to discriminate secure and insecure attachment relationships in both story lines with some indicators. Thus, the story length (WC) shows a small effect size in *The Stolen Bike* (Cohen's $d = 0.54$) and a large effect size in *The Present* (Cohen's $d = 0.71$). Sentence length (WPS) produces a large effect size (Cohen's $d = 0.84$) in *The Stolen Bike* and a small effect size in *The Present* (Cohen's $d = 0.33$). This effect might be due to the fact that in the *The Stolen Bike* story line sentence and cognitive complexity are more relevant in ASCT coding criteria. Negations (negate) produces a large effect size in both *The Stolen Bike* (Cohen's $d = 0.92$) and *The Present* (Cohen's $d = 0.83$). When an insecure relationshp is present children have difficulties to answer, presenting avoidance and negation. The affective processes (affect) produce a medium effect size in *The Stolen Bike* (Cohen's $d = 0.5$) and a small effect size in *The Present* (Cohen's $d = 0.41$). The negative emotions (negemo) produce a medium effect size in *The Stolen Bike* (Cohen's $d = 0.78$) and a small effect size in *The Present* (Cohen's $d = 0.27$). The positive emotions (posemo) has a small effect size in *The Present* and no effect in *The Stolen Bike*.

Finally, the additional speech cues included in this study, response eliciting questions (REQ) and pauses, produced consistent medium and large effect sizes in both corpora. REQ produced large effect sizes in *The Stolen Bike* (Cohen's $d = 0.8$) and *The Present* (Cohen's $d = 1.25$). The measure of pauses in the narrative flow produced medium effect sizes in *The Stolen Bike* (Cohen's $d = 0.6$) and *The Present* (Cohen's $d = 0.64$).

In summary, LSA, REQ and pauses produced consistent effect sizes across the corpora. In the case of LIWC, only negative expressions produced consistent large effect sizes across the corpora. Other indicators varied in effect sizes, affected by corpus characteristics. *The Stolen Bike* story being more representative of insecure attachment relationships than *The Present*. Similarly, semantic information was more important to detect secure attachment relationships than insecure attachment relationships. LIWC measures were significantly related mainly to insecure story detection in this specific story, but also provided strong indicatives for security (WC).

Therefore, the study shows that it is possible to explore attachment relations by computational means. Computational modelling reduces time and eases classification in unfinished story classification. However, an in-depth study is required to further explore and expand the possibilities of this approach on a wider dimension exploring the predictive capabilities of the different indicators.

Future lines include the extension of the current corpora adding other incomplete stories included in [22] for a more in-depth analysis of attachment relationships. The corpus-based computational narrative analysis would also allow to further study theoretical questions in attachment such as representational differences for mothers and fathers.

The ability to detect children affective states computationally based on story transcriptions opens the possibility of computationally detecting affection based on narratives in a wide variety of contexts. Applying computational means to the study of cognitive affective phenomena has already shown to be very promising and full of ongoing challenges [21].

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