A Cognitive Framework for Understanding Counterintuitive Stories

M. Afzal Upal

Defence Research & Development Canada, Toronto, ON
Afzal.Upal@drdc-rddc.gc.ca

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.

1998 ACM Subject Classification I.2.7 Natural Language Processing

Keywords and phrases counterintuitive concepts, memory

Digital Object Identifier 10.4230/OASIcs.CMN.2014.222

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,

5th Workshop on Computational Models of Narrative (CMN'14).
Editors: Mark A. Finlayson, Jan Christoph Meister, and Emile G. Bruneau; pp. 222–240

OpenAccess Series in Informatics
Schloss Dagstuhl – Leibniz-Zentrum für Informatik, Dagstuhl Publishing, Germany

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

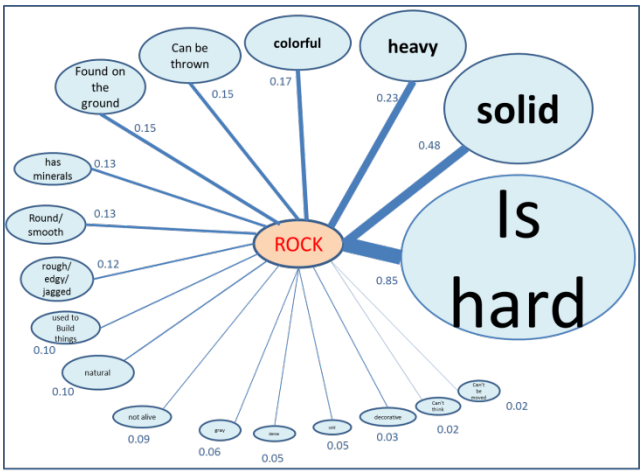

Figure 1 Most commonly mentioned features of the category rock along with the proportion of participants who mentioned it (indicated as a weight for a node).

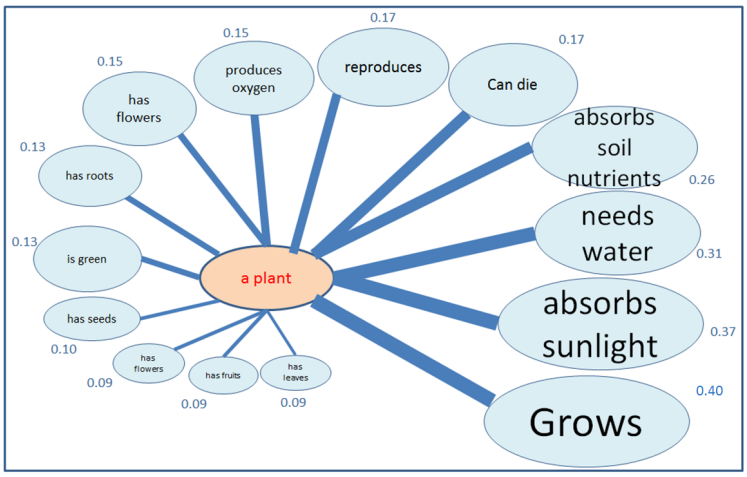

Figure 2 Most commonly mentioned features of the category plant.

"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.

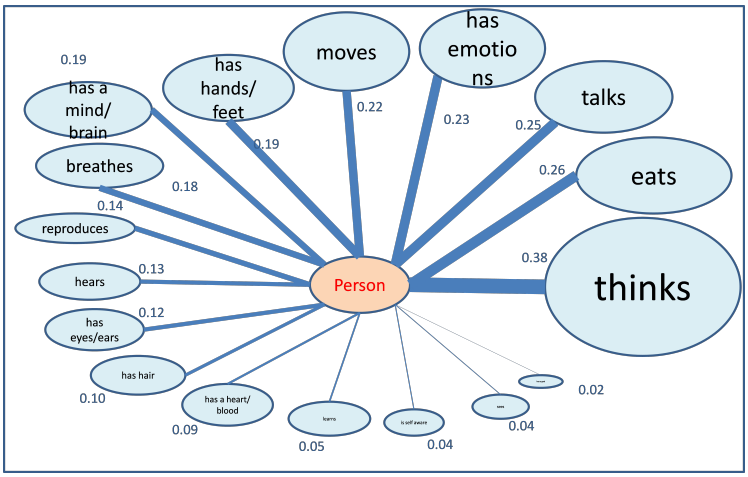

Figure 3 Most commonly mentioned features of the category person.

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 superhero (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 superhero (12)
thinks (13)	can fly (14)	is a superhero (11)	can move (13)	can eat (13)	is undetected (11)
can fly (12)	can move (14)	rescues people (10)	has hands/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 superpowers (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.

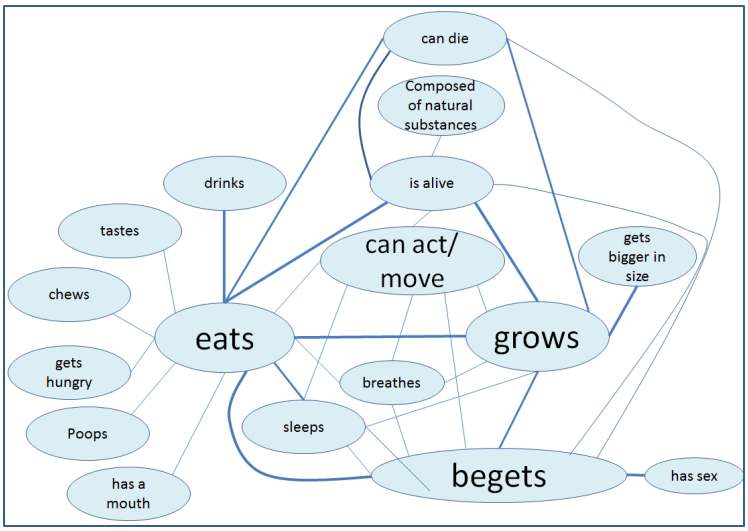

Figure 4 Context-based view of the biology domain.

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.

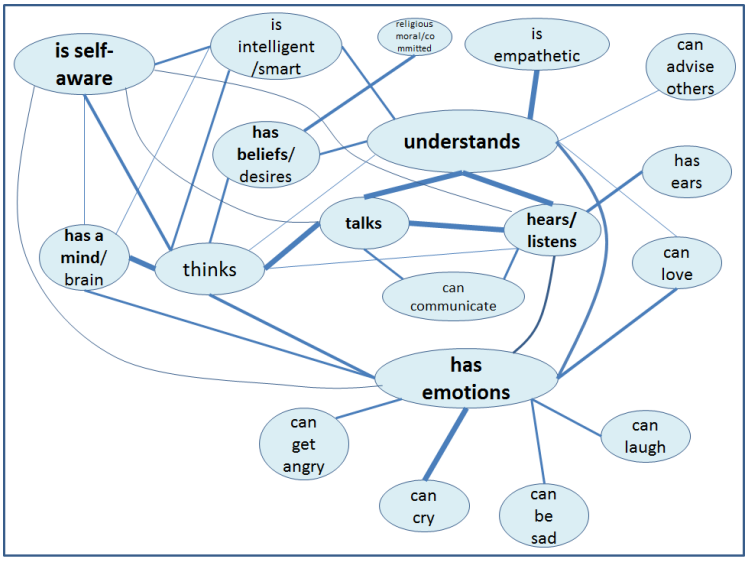

Figure 5 Context-based view of the mentality domain.

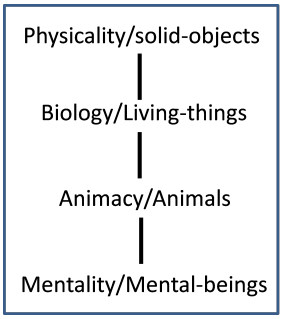

Figure 6 Expectation set hierarchy.

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).

References

1 F. C. Bartless. *Remembering*. Cambridge University Press, Cambridge, UK, 1932.
2 P. Boyer. *The Naturalness of Religion Ideas: A Cognitive Theory of Religion*. University of California Press, Berkley, CA, 1994.
3 P. Boyer. *Religion Explained: The evolutionary origins of religious thought*. Basic Books, New York, NY, 2001.
4 D. Sperber. *Explaining culture: A naturalistic approach*. Blackwell Publishers, Malden, MA, 1996.
5 M. A. Upal. An Alternative Account of the Minimal Counterintuitiveness Effect. *Journal of Cognitive Systems Research*, 11(2), 194-2003, 2009.
6 J. L. Barrett. Coding and Quantifying Counterintuitiveness in religious concepts: Theoretical and methodological reflections. *Method and Theory in the Study of Religion*, 20, 308-338, 2008.
7 W. Kintsch and L. Greene. The role of culture specific schemata in the comprehension and recall of stories. *Discourse Processes*, 1(1), 1-13, 1978.
8 J. L. Barrett, and M. Nyhoff. Spreading non-natural concepts: the role of intuitive conceptual structures in memory and transmission of cultural materials. *Cognition and Culture*, 1(1), 69-100), 2001.
9 R. Erdoes and A. Oritz. *American Indian Myths and Legends*. Pantheon Books, New York, NY, 1984,

10 P. Boyer and C. Ramble, Cognitive templates for religious concepts. *Cognitive Science*. 25, 535-564, 2001.

11 A. Norenzayan et al. Memory and Mystery: The Cultural Selection of Minimally Counterintuitive Narratives. *Cognitive Science*, 30, 531-553, 2006.

12 M. A. Upal. Memory, Mystery and Coherence: Does the presence of 2-3 counterintuitive concepts predict cultural success of a narrative? . *Cognition and Culture*, 11(1-2), 23-48, 2011.

13 A. C. Graesser, M. Singer, and T. Trabasso. Constructing inferences during narrative text comprehension. *Psychological Review*, 101, 371-395, 1994.

14 W. Kintsch. *Comprehension*. Cambridge University Press, Cambridge, MA, 1998.

15 M. A K. Halliday and R. Hasan. *Cohesion in English*. Longman, London, UK, 1976.

16 T. Trabasso et al. Explanatory inferences and other strategies during comprehension and their effects on recall, in *Sources of Coherence in Reading*, R.F. Larch and E.J. O'Brien (Eds). Erlbaum, Hillsdale, NJ, 1995.

17 S. Kim. Causal bridging inference: A cause of story interestingness. *British Journal of Psychology*, 90, 57-71, 1999.

18 R. C. Schank and R. Abelson. *Scripts, plans, goals, and understanding: An inquiry into human knowledge*. Lawrence Erlbaum Associates, Hillsdale, NJ, 1977.

19 R. C. Schank. *Dynamic Memory Revisited*. Cambridge University Press, New York, 1999.

20 J. Suls. Cognitive Processes in humor appreciation, in *Handbook of Humor Research*, P.E. McGhee and J.H. Goldstein, (Eds), Springer-Verlag, New York, 1983.

21 M. A. Upal. Role of Context in Memorability of Intuitive and Counterintuitive Concepts. in *Proceedings of the 27th Annual Meeting of the Cognitive Science Society*. Lawrence Erlbaum Press, 2005.

22 G. P. Gigerenzer, P. Todd, and T.A. Group. *Simple heuristics that make us smart*. Oxford University Press, New York, 1999.

23 R. Zwaan. Effect of genre expectations on text comprehension. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. 20, 920-933, 1994.

24 M. Pazzani. The influence of prior knowledge on concept acquisition: Experimental and computational results. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. 17(3), 416-432, 1991.

25 J. T. Guthrie et al. Motivation and Cognitive predictors of text comprehension and reading amount. in *Scientific Studies of Reading* , 3, 231-256, 1999.

26 E. Heit. Influence of prior knowledge on selective weighting of category members. *Journal of Experimental Psychology: Learning, Memory, and Cognition*. 24, 712-731, 1998.

27 L. Gonce, M. A. Upal, R. Tweney, J. Slone. Role of Context in the Recall of Counterintuitive Concepts. *Cognition and Culture*. 6(3-4), 521-547, 2006.

28 M. A. Upal. What is More Memorable Counterintuitive Concepts Interpreted Metaphorically or Literally? in *Proceedings of the 29th Annual Meeting of the Cognitive Science Society*. Lawrence Erlbaum Press, 2007.

29 M. A. Upal et al., Contextualizing counterintuitiveness: How context affects comprehension and memorability of counterintuitive concepts. *Cognitive Science*. 31(3), 415-439, 2007.

30 R. N. McCauley. *Why Religion is Natural and Science is not*. 2011, New York, NY: Oxford University Press, 2011.

31 McRae, K., et al., Semantic feature production norms for a large set of living and non-living things. *Behavior Research Methods, Instruments, & Computers*. 7(4), 547-559, 2005.

32 D. P. Vinson and G. Vigliocco. A semantic analysis of grammatical class impairments: semantic representations of object nouns, action nouns and action verbs. *Journal of Neurolinguistics*. 15(3-5), 317-351, 2002.

33 M. H. Ashcraft, M.H., Property norms for typical and atypical items from 17 categories: a description and discussion. *Memory and Cognition*. 6(3), 227-232, 1978.

34 Y. Russell. What is counterintuitive? Religious cognition and natural expectation. *Review of Philosophy and Psychology*. 4(3), 2013.

35 S. Atran. *In Gods We Trust: Evolutionary Landscape of Religion*. Oxford University Press, Oxford, MA, 2004,

36 M. Harmon-Vukic and D.J. Slone. The Effect of Integration on Recall of Counterintuitive Stories. *Cognition and Culture*, 9(1-2), 57-68, 2009.

37 M. Harmon-Vukic, M.A. Upal, and K. Sheehan, Understanding the Memory Advantage of Counterintuitive Concepts. *Journal of Religion, Brain & Behavior*, 2, 2012.

38 Frassinelli, D. and A. Lenci. Concepts in context: evidence from a feature-norming study. in *Proceedings of the 34th Annual Conference of the Cognitive Science Society*. Lawrence Earlbaum, 2012.

39 P. J. Waddill, M. A. McDaniel (1998)Distinctiveness effects in recall: Differential processing or privileged retrieval. *Memory & Cognition*, 26, 108-120, 1998.