Constructing Spatial Representations from Narratives and Non-Narrative Descriptions: Evidence from 7-year-olds*

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Abstract

Although narratives often contain detailed descriptions of space and setting and readers frequently report vividly imagining these story worlds, evidence for the construction of spatial representations during narrative processing is currently mixed. In the present study, we investigated 7 year old children's ability to construct spatial representations of narrative spaces and compared this to the ability to construct representations from non-narrative descriptions. We hypothesized that performance would be better in the narrative condition, where children have the opportunity to construct a multi-dimensional situation model built around the character's motivations and actions. Children listened to either a narrative that included a character traveling between 5 locations in her neighbourhood or a description of the same 5-location neighbourhood. Those in the narrative condition significantly outperformed those in the description condition in constructing the layout of the neighbourhood locations. Moreover, regression analyses revealed that whereas performance on the narrative version was predicted by narrative comprehension ability, performance on the description version was predicted by working memory ability. These results suggest the possibility that building spatial representations from narratives and non-narratives may engage different cognitive processes.

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1 Introduction

The subjective experience of readers and listeners of narratives is often one of being transported into the narrative world, vicariously participating in the unravelling events [7]. Individuals may "feel" hot sand beneath their feet as a story protagonist walks along a beach or "see" the destruction caused by a tornado to a character's house. To the experiencer, narrative processing, with the imagination, perspective-taking, and emotional engagement that it encourages and induces, may seem qualitatively different from non-narrative processing. Common, subjective experience suggests that narrative processing is a feat of the imagination, often including visuospatial components [6, 12, 27]. Space and setting (the *where*) are the

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components of narrative that are most often associated with these visuospatial representations [9]. Yet, experimental evidence for representations of space in narratives is currently mixed. There is little doubt that most individuals are *able to* form spatial representations of narratives, but whether they do so spontaneously is another matter [9, 14, 29].

Representing narrative spaces may be important for several reasons, both outside and within the narrative world. Creating an accurate representation of space in narrative may be important for navigation in the real world. Narratives told by foraging peoples place great emphasis on "the lay of the land, travel routes, or orienteering-knowledge critical to undertaking extended hunting, trading, or visiting trips, which are an important part of forager life" [20, p. 243]. Additionally, accurately representing a narrative's space may be important for understanding events within the narrative. In some cases, understanding a causal sequence and making inferences may hinge on building an accurate spatial representation [9]. Although constructing a spatial representation may not be necessary for survival or comprehension in many cases, one often finds that storytellers include descriptions of spaces and settings of the story world to add detail and colour to their narratives.

1.1 The situation model

Underlying the imaginative experience that many readers and listeners of narratives report is the construction of a situation model. During narrative processing, individuals create representations not only of word order and meaning, but also representations of the situation the text or spoken language is about [11, 24]. These representations of the situations described by the text are known as *mental models* [11] or *situation models* [24, 29]. The situations described by sentences are retained in memory and used to make judgments [1, 8, 9]). Situation models are multidimensional representations, created by combining the content of the text with prior knowledge, and may include temporal, spatial, causal, person and object, and intentional information [11, 29].

There is evidence to suggest that adults construct situation models along most of the major dimensions during narrative processing [28, 30], but, as mentioned above, experimental evidence for the construction of spatial situation models is currently mixed.

1.2 Children's spatial situation models

To our knowledge, there has been no investigation of children's spatial situation model construction during narrative processing. Studies investigating other aspects of children's situation models have found that children track characters' physical [19, 26], mental [5, 17], and spatiotemporal perspectives [5]. Although they have not directly assessed children's ability to construct spatial situation models, these studies provide strong evidence that children spontaneously track characters' perspectives and movements. It may be reasonable to expect that they should also represent the space in which the characters are perceiving and moving. Indeed, Bruner has argued that "the inseparability of character, setting, and action must be deeply rooted in the nature of narrative thought. It is only with difficulty that we can conceive of each of them in isolation" [2, p. 39]. In other words, it is potentially difficult to construct a situation model that lacks one of the major dimensions; a character who acts without goals, an occurrence without apparent cause, or an event devoid of setting. Perhaps we should not conceive of the dimensions of situation models as independent of one another, but, rather, as deeply intertwined.

Outside the domain of narrative, Uttal, Fisher, and Taylor [23] compared eight- and 10-year-old children's and adults' ability to create representations of space from descriptions to representations created from maps. Participants heard a description of a six-room building or saw a map of the same space and were then asked to assemble the space using six cards. Eight-year-old children who heard the description had difficulty with the task; their situation models seemed to be tied to the sequential order in which locations were mentioned.

Although this study suggests that children have difficulty constructing spatial representations from language when no visual information is available, it tells us little about how children may be able to create spatial situation models during *narrative* comprehension. Perhaps representations created during narrative processing are qualitatively different from representations created from descriptions, or perhaps this ability is similarly limited during narrative processing.

The process of constructing a spatial representation from a narrative may be fundamentally different than that from a description. In the former, one is following a character through space, whereas in the latter, one must conceive of the space from a characterless perspective. The provision of character, actions, motivations, and time may mean the construction of the spatial situation model is more character-driven than in the case of a non-narrative description, in which a multidimensional situation model cannot be constructed. Thus, when spatial information is presented in the form of a narrative, the system that builds spatial situation models may be engaged more readily than in the case of a non-narrative description. The construction of spatial representations from non-narrative descriptions may be more of a working memory process—something akin to memorizing a grocery list.

1.3 Outline of experiment

The experiment described here aimed to discover what children's spatial situation models of narratives look like—the amount and type of detail they include, and how they may be different from spatial representations of non-narratives. We also included measures to attempt to uncover the abilities related to children's construction of situation models, such as language comprehension, general language ability, spatial ability, and working memory. If the construction of spatial situation models is indeed a different process depending on whether spatial information is presented in the form of a narrative or a non-narrative description, one may expect different abilities to be recruited, and, thus, success on each task may be associated with strengths in different areas.

The present experiment compared seven-year-old children's abilities to construct spatial representations of narratives and non-narrative descriptions. Seven-year-olds were chosen, because it is at this age that children begin regularly encountering narratives that they must mentally construct, without the support of any visuals. Canadian children, the sample that participated in the present study, typically begin reading short novels at this age and often hear stories read aloud in class. Additionally, we felt the task may be too complex for younger children (cf., e.g, [23]).

2 Method

2.1 Participants

Participants were 38 7-year-old children ($M = 7.55$ years, range = 7.17 to 8.0, $SD = 2.88$ months; 20 girls). All children were recruited through a laboratory database and were in Canadian second grade.

2.2 Task procedures

Spatial situation model (SSM) task. Children were randomly assigned to one of two conditions: *narrative* or *description* and heard one of one of two corresponding pre-recorded passages about a character's neighbourhood. Children in the *narrative* condition heard about a child (Molly or Max) who bakes cookies and delivers them to four locations in the neighbourhood. The relative position of the locations comes about through the character's movement through space; for example, the character is described as walking "over the bridge to the library that's across the river from her house." Children in the *description* condition heard a description of the same four locations without the presence of a character moving between them. The relative position of the locations was explicitly stated; for example, the library is described as being "across the river from Molly's house, over the bridge". The passages in both conditions were designed to be as similar as possible, with the critical difference between the two being the presence of a goal-driven character moving through space. The narrative passage also included a three-sentence introduction that presented the character's motivations for visiting the locations in the neighbourhood.

After having listened to the passage twice, participants in both conditions were presented with a box with the following three-dimensional model pieces placed randomly within it: house, fire station, veterinarian's office, library, toy store, road, river, and bridge, and were asked to build Molly's neighbourhood.

Coding. Participation was video recorded for later analysis. Two coders, the second blind to participant condition and the purpose of the study, provided a code for each participant based upon a screen capture image provided. The coding scheme used required participants to represent meaningful relations between locations in the neighbourhood. Participants received a score ranging from 0 to 5 based upon their placement of the five locations (the character's house and the four locations she visited.)

Narrative comprehension. Two stories were chosen from the Neale Analysis of Reading Ability Test [16], a standardized tool designed to assess children's reading accuracy and comprehension. Although the tool is designed to be a reading test, children listened to the stories, because the SSM task involved listening, rather than reading. After listening to each story on headphones, children are asked a series of comprehension questions.

Listening comprehension. The Listening Comprehension subtest from the Woodcock-Johnson Tests of Achievement [25], a measure of language comprehension, was administered. Participants listen to sentences and short passages of increasing difficulty and are asked to provide a word to complete the passage. Appropriate completion depends on having processed and comprehended the passage as a whole.

Picture vocabulary. Children completed the Picture Vocabulary subtest from the Woodcock-Johnson Tests of Achievement [25], as a measure of general language ability. In this expressive vocabulary test, participants are asked to provide a label for pictures of increasing difficulty.

Sentence Span. A sentence span test, a test of verbal working memory, adapted from the widely-used reading span test [4] by Swanson, Cochrane, and Ewers [21], was administered. In this task, participants are presented with sets of unrelated sentences on a screen and are asked to remember the last word from each sentence. To ensure participants are paying attention to sentences as a whole, they are asked a factual comprehension question about one

Table 1 Correlations between performance on narrative or description SSM versions and other measures.

	Narrative Comp.	Listening Comp.	Picture Vocab.	Mental Rotation	Sentence Span (WM)
Narrative SSM	.63**	.35	.18	.01	−.23
Description SSM	.27	.54*	.31	.08	−.53*

*) indicates correlation is significant at .05 level
**) indicates correlation is significant at .01 level.

of the sentences before being cued to recall the words. Participants only receive credit for recalling words on sets for which they have answered the comprehension question correctly.

Mental Rotation. A mental rotation test [13] was included as a measure of children's spatial ability. On this test, children are required to choose from four, candidate whole shapes the shape two pieces would make if put together. Items require mental translation and/or rotation of the pieces to arrive at the correct answer.

3 Results

3.1 Spatial situation model task

No gender differences were found, so results for both genders were analyzed together. Children in the narrative condition ($M = 3.44$, $SE = .25$) significantly outperformed those in the description condition ($M = 2.75$, $SE = .23$), $t(36) = 2.08$, $p = .045$.

3.2 Spatial situation model task performance and its predictors

Because it was hypothesized that different processes may underlie the construction of spatial representations depending on whether the information is presented in the form of a narrative or a description, the data were divided up by condition. Performance on the narrative version of the SSM task was significantly correlated with narrative comprehension scores ($r = .64$, $p = .006$). Performance on the description version of the SSM task was significantly correlated with listening comprehension scores ($r = .54$, $p = .014$) and sentence span (working memory) scores ($r = .53$, $p = .017$). See Table 1.

Multiple regression analysis was used to investigate whether certain abilities predicted performance on the narrative and description versions of the SSM task. Children's performance in the narrative condition was best predicted by narrative comprehension ($\beta = .72$, $p = .001$) and sentence span (working memory) ($\beta = -.49$, $p = .013$), explaining 51.2% of variance in narrative SSM task scores, Adjusted $R^2 = .516$, $F(2, 17) = 10.07$, $p = .002$. Children's performance in the description condition was best predicted by sentence span alone ($\beta = .53$, $p = .017$), explaining 23.8% of variance in description SSM task scores, Adjusted $R^2 = .238$, $F(1, 19) = 6.94$, $p = .017$.

4 Discussion

Children in the present study created more accurate external models of the neighbourhood in the narrative condition than in the description condition. Additionally, preliminary regression analyses suggest that different cognitive processes *may* be recruited to perform the narrative and description versions of the SSM task. Performance in the narrative condition was predicted by narrative comprehension scores and was negatively predicted by sentence span, whereas performance in the description condition was predicted by sentence span alone.

Note that these results were not necessarily predictable from the outset. Research in adult education has yielded mixed results when comparing undergraduates' performance on tests of material encountered in either a narrative or non-narrative (expository) text, with some studies showing a narrative advantage [10] and others showing no difference between genres [3]. Our study is the first, to our knowledge, to compare spatial representations constructed from narratives and non-narratives and to look at correlates of these abilities.

What is the reason for the observed advantage on the narrative task? There are three key ways in which the narrative and description versions differed. First, in the narrative, participants were presented with a character with specific goals (i.e., to deliver cookies) that motivated her to travel to the various locations. This may have given participants the opportunity to construct a multidimensional situation model that supported the construction of their spatial situation models. Perhaps including goals, characters, and actions through space scaffolds the construction of a spatial representation. In other words, reading or listening to a narrative may engage a different set of cognitive processes than a non-narrative [2].

Second, the narrative invited participants to take a perspective *within* the narrative, whereas the description may have encouraged participants to take more of a bird's eye view of the space. This distinction would be similar to that between route and survey perspectives, respectively. If participants are inclined to step into characters' shoes, as suggested by previous studies (e.g., [5, 15, 19]), perhaps they take on something of a route perspective. However, previous studies have demonstrated that adults' spatial representations are more or less the same whether they are derived from survey or route descriptions [18, 22]. It is possible that the same pattern will not hold for children. Follow-up studies will investigate the underlying reasons for the advantage on the narrative task my manipulating factors such as the opportunity to take a perspective within the space.

Third, it may simply be the case that participants found the narrative more interesting, which served to maintain their attention. This explanation would suggest that the unique characteristics of the narrative, such as the opportunity to construct a multidimensional situation model or take a character's perspective, were not driving the effect, but rather that the narrative yielded superior performance because it was more engaging. Although this explanation cannot be entirely ruled out, there are two potential problems with it. If it were simply a matter of participants in one condition devoting more attention to the task than those in the other, one may have expected to see effects of passage length. The description version was substantially shorter than the narrative version. Additionally, interest is an inherently subjective matter. Indeed, children in both conditions reported enjoying the passages and the accompanying activity quite frequently.

The results of the correlational and regression analyses are most in line with the first interpretation. It is intriguing that performance on the narrative version of the task was most strongly associated with narrative comprehension, whereas performance on the description version was most associated with working memory. This lends support to an explanation that suggests that different cognitive processes support construction of spatial representations based on the two types of language (narrative versus description). Successful construction of spatial representations from narratives may depend on the ability to build situation model representations, whereas successful construction from descriptions may depend more on holding a series of propositions in working memory.

The possibility that children in the description group held verbatim representations of the sentences in memory could explain why children with stronger verbal working memory abilities had an edge in the task. The finding that narrative comprehension was a significant predictor of performance on the narrative version, but not the description version could be interpreted in a few ways. Children with strong narrative comprehension skills may demonstrate such strength because they are better at constructing spatial (and other types of) situation models. That is, the ability to create detailed and accurate situation models may bolster children's comprehension. Or, children may require a certain level of competence in their comprehension abilities to be able to process the sentences they have heard, before they begin to construct a situation model. However, the narrative comprehension measure, but not the listening comprehension measure predicted children's performance on the narrative SSM task, suggesting that there was something unique about narrative comprehension abilities involved in task success. Of course, the children who performed well on both the narrative comprehension measure and the narrative SSM task may just have been those who enjoy stories more. However, there remains the intriguing possibility that the effect is due to another reason; children who are better at visualizing and creating spatial situation models may be better comprehenders because of it.

4.1 Conclusions

The findings of the present study lend support to the idea that a special mode of narrative thought exists distinctly from non-narrative thought [2]. When presented with the exact same spatial information in narrative or non-narrative formats, participants had differential success. Furthermore, performance in each condition was associated with different abilities. These findings suggest that constructing spatial representations from narrative is, on average, easier than constructing representations from descriptions, but also raise intriguing questions about why this may be the case.

References

1 John D. Bransford, J. Richard Barclay, and Jeffery J. Franks. Sentence memory: A constructive versus interpretive approach. *Cognitive Psychology*, 3(2):193–209, 1972.

2 Jerome Bruner. Actual minds, possible worlds. *Cambridge, MA: Harvard University*, 1986.

3 Lawrence J. Cunningham and M. D. Gall. The effects of expository and narrative prose on student achievement and attitudes toward textbooks. *Journal of Experimental Education*, 58:165–175, 1990.

4 Meredyth Daneman and Patricia A. Carpenter. Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior*, 19(4):450–466, 1980.

5 Agnieszka M. Fecica and Daniela K. O'Neill. A step at a time: Preliterate children's simulation of narrative movement during story comprehension. *Cognition*, 116(3):368–381, 2010.

6 Rebecca Fincher-Kiefer. Perceptual components of situation models. *Memory & Cognition*, 29(2):336–343, 2001.

7 Richard J. Gerrig. *Experiencing narrative worlds: On the psychological activities of reading.* Yale University Press, 1993.

8 Arthur M. Glenberg, Marion Meyer, and Karen Lindem. Mental models contribute to foregrounding during text comprehension. *Journal of Memory and Language*, 26(1):69–83, 1987.

9 Georg Jahn. Three turtles in danger: Spontaneous construction of causally relevant spatial situation models. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 30(5):969–987, 2004.

10 Adrian S. Janit, Georgina S. Hammock, and Deborah S. Richardson. The power of fiction: Reading stories in abnormal psychology. *International Journal for the Scholarship of Teaching and Learning*, 5(1):1–14, 2011.

11 Philip N. Johnson-Laird. *Mental models: Towards a cognitive science of language, inference, and consciousness*. Harvard University Press, 1983.

12 William Langston, Douglas C. Kramer, and Arthur M. Glenberg. The representation of space in mental models derived from text. *Memory & Cognition*, 26(2):247–262, 1998.

13 Susan C. Levine, Janellen Huttenlocher, Amy Taylor, and Adela Langrock. Early sex differences in spatial skill. *Developmental Psychology*, 35(4):940–948, 1999.

14 Daniel G. Morrow. Spatial models created from text. In Herre van Oostendorp and Rolf A. Zwaan, editors, *Naturalistic Text Comprehension*, pages 57–78, Norwood, NJ, 1994. Ablex.

15 Daniel G. Morrow, Steven L. Greenspan, and Gordon H. Bower. Accessibility and situation models in narrative comprehension. *Journal of Memory and Language*, 26(2):165–187, 1987.

16 Marie D. Neale. *Neale analysis of reading ability: Manual*. ERIC, 1999.

17 Daniela K. O'Neill and Rebecca M. Shultis. The emergence of the ability to track a character's mental perspective in narrative. *Developmental Psychology*, 43(4):1032–1038, 2007.

18 Walter Perrig and Walter Kintsch. Propositional and situational representations of text. *Journal of Memory and Language*, 24(5):503–518, 1985.

19 Jaime Rall and Paul L. Harris. In Cinderella's slippers? Story comprehension from the protagonist's point of view. *Developmental Psychology*, 36(2):202–208, 2000.

20 Michelle Scalise Sugiyama. Food, foragers, and folklore: The role of narrative in human subsistence. *Evolution and Human Behavior*, 22(4):221–240, 2001.

21 H. Lee Swanson, Kathryn F. Cochran, and Cynthia A. Ewers. Working memory in skilled and less skilled readers. *Journal of Abnormal Child Psychology*, 17(2):145–156, 1989.

22 Holly A. Taylor and Barbara Tversky. Spatial mental models derived from survey and route descriptions. *Journal of Memory and Language*, 31(2):261–292, 1992.

23 David H. Uttal, Joan A. Fisher, and Holly A. Taylor. Words and maps: developmental changes in mental models of spatial information acquired from descriptions and depictions. *Developmental Science*, 9(2):221–235, 2006.

24 Teun Adrianus Van Dijk and Walter Kintsch. *Strategies of discourse comprehension*. Academic Press New York, 1983.

25 Richard W. Woodcock, Kevin S. McGrew, and Nancy Mather. *Woodcock-Johnson® III Tests of Achievement*. Itasca, IL: Riverside Publishing, 2001.

26 Fenja Ziegler, Peter Mitchell, and Gregory Currie. How does narrative cue children's perspective taking? *Developmental Psychology*, 41(1):115–123, 2005.

27 Rolf A. Zwaan. Embodied cognition, perceptual symbols, and situation models. *Discourse Processes*, 28:81–88, 1999.

28 Rolf A. Zwaan, Joseph P. Magliano, and Arthur C. Graesser. Dimensions of situation model construction in narrative comprehension. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 21(2):386–397, 1995.

29 Rolf A. Zwaan and Gabriel A. Radvansky. Situation models in language comprehension and memory. *Psychological Bulletin*, 123(2):162–185, 1998.

30 Rolf A. Zwaan, Gabriel A. Radvansky, Amy E. Hilliard, and Jacqueline M. Curiel. Constructing multidimensional situation models during reading. *Scientific Studies of Reading*, 2(3):199–220, 1998.