



# Kent Academic Repository

Nyhout, A. and O'Neill, D.K. (2017) *Children's Enactment of Characters' Movements: A Novel Measure of Spatial Situation Model Representations and Indicator of Comprehension*. *Mind, Brain, and Education*, 11 (3). pp. 112-120. ISSN 1751-2271.

## Downloaded from

<https://kar.kent.ac.uk/81938/> The University of Kent's Academic Repository KAR

## The version of record is available from

<https://doi.org/10.1111/mbe.12142>

## This document version

Author's Accepted Manuscript

## DOI for this version

## Licence for this version

UNSPECIFIED

## Additional information

Unmapped bibliographic data:LA - English [Field not mapped to EPrints]J2 - Mind Brain Education [Field not mapped to EPrints]AD - Department of Psychology, University of Waterloo, Canada [Field not mapped to EPrints]AD - Dr. Eric Jackman Institute of Child Study, University of Toronto, 252 Bloor Street West, Toronto, ON M5S 1V6, Canada [Field not mapped to EPrints]DB - Scopus [Field not mapped to EPrints]M3 - Article [Field not mapped to EPrints]

## Versions of research works

### Versions of Record

If this version is the version of record, it is the same as the published version available on the publisher's web site. Cite as the published version.

### Author Accepted Manuscripts

If this document is identified as the Author Accepted Manuscript it is the version after peer review but before type setting, copy editing or publisher branding. Cite as Surname, Initial. (Year) 'Title of article'. To be published in *Title of Journal*, Volume and issue numbers [peer-reviewed accepted version]. Available at: DOI or URL (Accessed: date).

## Enquiries

If you have questions about this document contact [ResearchSupport@kent.ac.uk](mailto:ResearchSupport@kent.ac.uk). Please include the URL of the record in KAR. If you believe that your, or a third party's rights have been compromised through this document please see our [Take Down policy](https://www.kent.ac.uk/guides/kar-the-kent-academic-repository#policies) (available from <https://www.kent.ac.uk/guides/kar-the-kent-academic-repository#policies>).

Children's enactment of characters' movements:  
A novel measure of spatial situation model representations and indicator of comprehension

Angela Nyhout<sup>a,b,1</sup> & Daniela K. O'Neill<sup>a</sup>

<sup>a</sup>University of Waterloo, 200 University Avenue West,  
Waterloo, Ontario, Canada, N2L 3G1

<sup>b</sup>Corresponding author, [angela.nyhout@utoronto.ca](mailto:angela.nyhout@utoronto.ca)

---

<sup>1</sup> Angela Nyhout is now at the Dr. Eric Jackman Institute of Child Study, University of Toronto, 252 Bloor Street West, Toronto, Ontario, Canada, M5S 1V6.

# CHILDREN'S ENACTMENT OF CHARACTERS' MOVEMENTS

## Abstract

A story's space or setting often determines and constrains the actions of its characters. We report on an experiment with 106 7- through 8-year-old children in which, using a novel enactment task, we measured children's representation of a story character's movement during story listening. We found that children were more likely to enact movements that were explicitly-stated in the passage than those they had to infer based on their situation model representation of the house and the character's location within it. We found that this ability to infer movements was significantly predictive of children's narrative comprehension after controlling for oral comprehension, vocabulary, working memory, and enactment of explicitly-stated movements. We discuss the role of spatial situation models in comprehension and potential future uses for this enactment task in research and classrooms.

Keywords: situation models; narrative comprehension; spatial representations

## CHILDREN'S ENACTMENT OF CHARACTERS' MOVEMENTS

Children's enactment of characters' movements:

A novel measure of spatial situation model representations and indicator of comprehension  
Narratives place a number of representational demands on their readers and listeners. In order to accurately and fully comprehend a story's unfolding events, readers and listeners must track the actions, locations, and goals of multiple characters, and the order in which events take place. Despite these demands, the human ability to represent narratives is surprisingly sophisticated from a young age.

A large body of research exists looking at adults' ability to construct representations of narratives (e.g., Radvansky, Zwaan, Curiel, & Copeland, 2001; Rapp & Taylor, 2004; Zwaan & Radvansky, 1997). The detailed and dynamic representations constructed and updated during narrative comprehension often include details of the physical and motivational causes of events, the story characters involved, the space and location in which events take place, and the temporal sequence of events (Zwaan & Radvansky, 1998). These representations are known as situation models (Kintsch & van Dijk, 1983) or mental models (Johnson-Laird, 1983).

Although fewer studies have investigated children's situation model representations of narratives, these studies have revealed that, by the time they arrive at school, children are able to track characters' visual (Rall & Harris, 2000; Ziegler, Mitchell, & Currie, 2005), mental (O'Neill & Shultis, 2007), and spatiotemporal perspectives (Fecica & O'Neill, 2010). That is, by age 4 or 5, children construct detailed and accurate character-centred representations of narrative worlds. If children represent the perspectives and actions of characters, is it also reasonable to expect that they represent the space or setting within which characters perceive and act?

### **Representations of space in narrative**

Space and setting are integral parts of narratives, often confining and determining the actions of story characters. Indeed, in some cases, it is difficult, if not impossible, to accurately

represent a character's thoughts and actions without also representing the environment in which a story's events unravel. In the words of Jerome Bruner (1986), "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." (p. 39).

To date, studies on whether and when adults track and represent spatial information during narrative processing provide somewhat mixed results. The general conclusion seems to be that adults do encode and track spatial information (e.g., Radvansky & Copeland, 2010), though whether they do so is somewhat dependent on a number of factors (de Vega, 1995; O'Brien & Albrecht, 1992; Sundermeier, van den Broek, & Zwaan, 2005). These factors can include features of the text, such as how determinate, continuous, and condensed a spatial description is (Zwaan & van Oostendorp, 1993), and features of the task given to them. In particular, adults seem more likely to represent spatial information when explicitly instructed to do so (Zwaan & Radvansky, 1998; Zwaan & van Oostendorp, 1993; 1994), when given a given a map of the setting before reading (Morrow et al., 1987; 1989), and when a spatial representation is causally relevant (Jahn, 2004). Recently, Smith and O'Brien (2012) found that adults tracked spatial information whenever they encountered textual cues to spatial information that had been mentioned earlier.

Other work suggests that adults integrate complex relationships between dimensions of narrative into their situation models. Adults in one set of experiments read about a character who completed either a long-duration activity (e.g., listening to a whole lecture) or a short-duration activity (e.g., listening to just the introduction to a lecture) on a walk from the library to the bar (Rapp & Taylor, 2004). Those who heard about the long-duration activity took longer to respond to a reference the the character's origin location (e.g., the bar) than those who heard about the

short-duration activity, suggesting their representation of the spatial layout was modulated by the length of the activity, as the origin was less accessible to those in the long-duration version than the short-duration version. In this case, adults appeared to use the complex interrelationship between space, character movement, and the character's goals to build their situation models.

A few studies have now begun to focus on children's ability to represent space in narrative and non-narrative passages. Ziegler and Acquah tested whether 5- to 9-year-old children were able to represent a character's physical surrounding from a *non-narrative* passage, using the support of a brief presentation of an image of the scene. Children touched a screen to identify objects to the character's left, right, front, and back. Children were faster and more accurate at identifying objects that were in front of or behind the character than objects to the character's left or right. This finding suggests that children were adopting an internal (first-person) perspective of the scene, rather than an external (third-person perspective), because the front-back difference is more salient from a first-person perspective than the left-right difference. No such asymmetry should be expected if one has adopted a third-person perspective. This finding suggests that children construct spatial situation models from characters' perspectives from a non-narrative passage.

A recent study compared seven- and eight-year-old children's ability to construct small models of neighbourhoods based on information encountered in a narrative or a non-narrative description (Nyhout & O'Neill, 2013). Children heard either a short narrative about a character delivering cookies around her neighbourhood to five different locations, or a non-narrative description of the same five locations. They were then given small model pieces of the locations from the passage and were asked to lay them out to reproduce the neighbourhood they had heard about. Children's models were coded for the preservation of important spatial relations, such as

the fact that the character's house was beside a river. Children were reasonably accurate in their recall of the neighbourhood's locations, and, interestingly, had better recall for the neighbourhood locations when encountered in a narrative than in a non-narrative description, suggesting differences between narrative and non-narrative processing.

Using an adapted version of the classic spatial situation model paradigm designed by Morrow, Greenspan, and Bower (1987) for a younger population, Barnes, Raghubar, Faulkner, and Denton (2014) investigated whether nine- to 16-year-olds were able to track a character's location within a multi-location setting. Children were familiarized with a physical model of a multi-stall marketplace, with each stall containing a set of unique items, prior to reading a narrative taking place there. Periodically, the narrative was interrupted with probes listing items that were, or were not, in the stall that the character was currently visiting. Children had to respond by key press to indicate whether the items were paired or not paired in the model. Children were faster to respond to items in the character's present location, and to items that were located at stalls the character passed on the way to his destination but that had not been mentioned, than to items elsewhere in the marketplace. Thus, children were relying not only on explicitly stated information in the text, but also on information that could be inferred based on the situation model they had constructed earlier from the physical model.

In both studies, children's performance on the respective tasks was found to be predictive of their narrative comprehension abilities, suggesting that the ability to construct spatial representations of narratives may in some way enrich the situation model representations being built and may support comprehension. However, neither study investigated children's ability to construct spatial representations in real-time, *during* narrative processing. In Nyhout and O'Neill's (2013) study, children's spatial representations were collected after listening to the

narrative, whereas in Barnes and colleagues' (2014) study, children were presented with a physical model of the narrative world and thus did not have to construct it on their own based on the information presented in the narrative. Characterizing children's representations during narrative comprehension is important because of the relevance of these representations to online comprehension processes such as comprehension monitoring and inferencing (e.g., Long & Chong, 2001; Van der Schoot, Reijntjes, van Lieshout, 2012).

The present study

In the present study, we asked whether 7- and 8-year-old children are able to represent the space in which a narrative's events are taking place *during* narrative processing. This age group was chosen based on previous studies of children's spatial situation models (Barnes et al., 2014; Nyhout & O'Neill, 2013). We used an enactment measure, in which children were given a small figurine of the story character and were asked to act out the story that took place in a 2-storey home as it was narrated through computer speakers. We compared children's ability to enact a character's movement up or down a staircase in cases where this was explicitly mentioned with cases where this movement had to be inferred, based on the spatial constraints of the story space. Specifically, we were interested in whether children would make these enacted "up/down stairs" movements (i.e., move the figurine as though it was going up/down stairs) on key sentences. These movements were not critical for comprehension of the passage. Therefore, enactment reflected a tendency to spontaneously represent the spatial layout of the home in the story and the character's location within it. In addition to observing whether children would enact these inferred movements, we were also interested in the extent to which their performance on this measure was predictive of their narrative comprehension, after controlling for other related abilities.



## Method

*Participants*

The study included 106 7- and 8-year-old children ( $M = 7.78$ ,  $SD = 0.52$ , range = 6.92 to 9.00 years, 52 girls). Children were recruited through an existing laboratory database of families who were interested in participating in language development research studies. Demographic information was not formally collected. Participating children were representative of the community from which they were drawn, and the majority were Caucasian and from middle-SES homes.

*Character movement task*

*Stimuli.* The story, *Jamie Gets Ready for Summer Camp*, was pre-recorded by an adult female and presented over computer speakers. The story describes the preparatory activities of a character, Jamie, as he/she gets ready for adventure camp. There were four critical sentences included in the story, two of which stated that Jamie went up/down the stairs (non-inferred movement) and two implied such movement (inferred movement). A full transcript of the story can be found in the Appendix.

For the non-inferred movement sentences, Jamie's passage down (*Jamie went downstairs to look for some sunscreen*) or up the stairs (*Jamie went upstairs to his mom's room*) was explicitly stated. For the inferred movement sentences, Jamie's passage up (*He went to his mom's room to ask her if she knew where his backpack was*) or down the stairs (*Jamie picked up his backpack off the playroom floor*) could be inferred only by tracking the relation between Jamie's origin and destination, because it was not explicitly stated in the narration. A playroom was chosen, because of its lack of a canonical location, unlike kitchens or bedrooms. Note that children were not explicitly cued to enact these stair movements in the pre-task instructions, so

## CHILDREN'S ENACTMENT OF CHARACTERS' MOVEMENTS

any such movements were driven by the child's own comprehension and representation of the passage. We reasoned that if children were representing the space through which Jamie was moving, then they should have moved Jamie up or down the stairs if his destination location was on a different floor than his current location.

*Procedure.* Children were seated at a table with the experimenter. A space of approximately 2' x 3' on the table directly in front of the child was clear for the child to carry out the enactment of the story, as described below.

Children were given a small figurine of Jamie, with the gender of the character matched to that of the child. They were given the following instructions, "*This is Jamie. You're going to hear a story about Jamie getting ready for his/her very first day of summer camp. What I want you to do is just move Jamie around to act out the story like it's telling you about on the computer. Are you ready?*" The experimenter then clicked a mouse button to play the first sentence of the story. The experimenter clicked to present each subsequent sentence, which she did when the child had clearly finished enacting the previous sentence (by bringing the figurine to a rest for approximately 500ms). Children's entire enactment of the story was video recorded for later coding.

Part way through the story, we conducted a comprehension check by asking children after the sentence "*There it was, on the coffee table*", "What did Jamie find on the coffee table?". All participants answered this question correctly ("sunscreen", "sun lotion", and "sun cream" were all accepted), suggesting they were attending to the story and tracking the character's goals.

*Coding.* The video recordings of each child's enactment were coded for four critical movements, two non-inferred and two inferred, that involved the character moving up or down

the stairs. Each child therefore received a *non-inferred* score between 0 and 2, an *inferred* score between 0 and 2, and an overall score between 0 and 4.

During the enactment phase for each of the four critical sentences (i.e., while the sentence was playing until the child's movement stopped and the next sentence began), children's movement of the figurine was coded for spontaneous, unambiguous stair movements. These movements involved, for upstairs movements, lifting the figurine up into the air off the table or slanting the figurine's front upward and tapping it on the table, and for downstairs movements, moving the figurine off the edge of the table to a lower finishing point or slanting the figurine's front downward and tapping it on the table. Recall that children were not explicitly cued to enact these stair movements.

One coder, blind to the purpose of the study, coded all 106 video recordings of children's enactments, while a second coder coded 32 (30%) of the video recordings. Coding agreement was very good (89%, Cohen's  $\kappa = .78$ ), with the two coders agreeing on 114 of the 128 coding decisions they both made (4 decisions for each of 32 participants). Coders were blind to children's performance on the other measures, detailed below.

#### *Other measures*

Children also completed four tasks measuring their narrative comprehension, oral comprehension, verbal ability, and verbal working memory. The order of presentation of these tasks, along with the Character Movement task, was counterbalanced. Because we were interested in whether performance on our task would predict children's narrative comprehension, we included a narrative comprehension measure. We also included measures of oral comprehension, verbal ability, and verbal working memory, given their relationship to narrative

## CHILDREN'S ENACTMENT OF CHARACTERS' MOVEMENTS

comprehension (Cain, Oakhill, & Bryant, 2004), to investigate whether our task would predict variance in narrative comprehension over and above these other abilities.

*Narrative comprehension.* Children completed an adapted version of the Narrative Analysis of Reading Ability (NARA; Neale, 1997), a widely-used measure of children's narrative comprehension that has been used previously in studies of children's embodied narrative representations (e.g., Berenhaus, Oakhill, & Rusted, 2015). From the original set of narratives included in the NARA, we selected and recorded two (*Ali* and *The Dragon*) that were at an appropriate level of difficulty for 7- and 8-year-old children. After listening to each narrative, children answered 8 comprehension questions.

*Oral comprehension.* Children completed the Oral Comprehension subtest of the Woodcock-Johnson Tests of Achievement (Woodcock, McGrew, & Mather, 2001). This task, which uses a cloze procedure, requires children to select an appropriate word to finish a sentence or passage of increasing difficulty that has been presented aurally.

*Verbal ability.* Children completed the Picture Vocabulary subtest of the Woodcock-Johnson Tests of Achievement (Woodcock et al., 2001). This task requires children to label pictures of increasing difficulty.

*Verbal Working Memory.* Children completed an adapted version of the Reading Span test (Dahneman & Carpenter, 1980), modeled upon an adapted Sentence Span version for children (Swanson, Cochran, & Ewers, 1989). In this task, children read sets of unrelated sentences and are instructed to recall the last word from each sentence. Prior to being asked to recall the words, children are asked a comprehension question about one of the sentences to ensure they have paid attention to the sentences as a whole. Children only receive credit for recalling words in sets for which they have correctly answered the comprehension question.

## Results

*Character movement task*

We compared children's enactment of the character's non-inferred and inferred movements during story processing. Children enacted significantly more non-inferred sentence movements ( $M = 1.37, SD = .76$ ) than inferred sentence movements ( $M = .57, SD = .79$ ),  $z = -6.873, p < .001$ . Table 1 displays the number of children out of the total 106 participants enacting 0, 1, or 2 of the non-inferred and inferred movements, as well as the number enacting 0, 1, 2, 3, or 4 total movements. For the non-inferred movements, there was no significant difference in the frequency of children's enactment of the movement corresponding to the sentence, "*Jamie went downstairs to look for some sunscreen*" ( $M = .71, SD = .46$ ) than the sentence "*Jamie went upstairs to his mom's room*" ( $M = .66, SD = .48$ ),  $p = .369$ . For the inferred movements, children were marginally, though not significantly, more likely to enact the (upstairs) movement corresponding to the sentence, "*He went to his mom's room to ask her if she knew where his backpack was*" ( $M = .32, SD = .47$ ) than the (downstairs) movement corresponding to the sentence, "*Jamie picked up his backpack off the playroom floor*" ( $M = .25, SD = .43$ ),  $p = .074$ .

*Relation between character movement task performance and narrative comprehension*

Table 2 displays the correlations between variables. A significant correlation was found between narrative comprehension and inferred movements, but not between narrative comprehension and non-inferred movements. We were also interested in whether children's performance on the character movement task predicted their narrative comprehension abilities. Table 3 displays the results of a hierarchical regression, conducted to investigate this possibility. In the first step (Model 1), we added age, oral comprehension, vocabulary (general language ability), and verbal working memory as predictors. This model was significantly predictive of

## CHILDREN'S ENACTMENT OF CHARACTERS' MOVEMENTS

children's narrative comprehension,  $R^2_{adjusted} = .40$ ,  $SE = 2.7$ ,  $F(4,105) = 18.75$ ,  $p < .001$ . Oral comprehension and vocabulary, but not age and verbal working memory, were significant predictors. In the second step (Model 2), we included non-inferred and inferred movements from the character movement task. This model explained additional variance in narrative comprehension over and above the first model,  $R^2_{adjusted} = .44$ ,  $SE = 2.40$ ,  $F(6,105) = 14.48$ ,  $p < .001$ ,  $R^2_{change} = .04$ ,  $F_{change}(2, 99) = 3.84$ ,  $p = .025$ . Inferred movements were a significant predictor of narrative comprehension, whereas non-inferred movements were not. A third model, in which only non-inferred and inferred movements were entered as predictors, was significant,  $R^2_{adjusted} = .04$ ,  $SE = 3.12$ ,  $F(2,105) = 3.44$ ,  $p = .036$ . Inferred movements were a significant predictor of comprehension without controlling for other relevant variables.

We also conducted regression analyses in which either the inferred or non-inferred movements were the outcome variable, and the other measures were entered as predictors. For the regression model in which inferred movements were the outcome variable, only narrative comprehension was a significant predictor,  $B = 0.9$ ,  $SE B = 0.03$ ,  $\beta = 0.35$ ,  $t = 2.77$ ,  $p = .007$  [all other predictors  $p > .240$ ]. None of the predictors were significant for the regression model with non-inferred movements as the outcome.

### Discussion

Children's ability to track and represent a character's movements between an origin and destination location was tested in the present study. Children frequently enacted explicitly mentioned (non-inferred) movements between locations. They less frequently enacted movements that required them to make an inference about the character's path based on prior information presented in the passage. The ability to infer the character's movements significantly

predicted children's narrative comprehension abilities, even when controlling for other relevant abilities.

### **Children's enactment of inferred movements**

A child's ability to enact movements that were not explicitly stated, but had to be inferred relied on representing the spatial layout of the story's setting (e.g., there is a playroom on the main floor of Jamie's house), as well as the character's current location within it (e.g., Jamie is in the playroom). More specifically, enactment of inferred movements meant that children were (1) tracking the character's movements and, by so doing, (2) building up a spatial representation of the story world on-line, and (3) using this spatial framework to continue to track the character's movement and location to allow for correct inferences about movements to be made.

There could be a few explanations for cases when a child did not enact inferred movements. First, the child may have constructed a spatial representation of Jamie's house, but failed to represent the character's movement within it. Given that constructing the spatial representation would have initially relied upon tracking the character's movement, this possibility appears unlikely. Second, the child may have represented the space and the character's movement, but did not translate this into physical manipulation. Given that the movement of the figurine was quite simple and well within the motor repertoire of 7- and 8-year-olds, this explanation seems unlikely, especially because the nature of the movement was the same for non-inferred and inferred sentences. A third possibility, which we think is more likely, is that the child enacted only on a sentence-by-sentence basis, constructing representations of individual sentences, but not integrating these into a spatial situation model of Jamie's house. Thus they enacted these movements when they were explicitly stated but not when they had to be inferred.

## CHILDREN'S ENACTMENT OF CHARACTERS' MOVEMENTS

Because children overall in this study enacted inferred movements only about 25% of the time, one might argue that children of this age (7 and 8 years) actually do not spontaneously represent characters' movements along unmentioned paths requiring an inference. Recent research by Barnes and colleagues (2014) suggests that, by the age of 9, children are able to infer character movements, although their study did not include children younger than 9. The children in their study responded faster to objects that were along a character's unmentioned path than to objects in other locations after they had memorized the story's setting using a physical model. Note that although the construction of spatial situation models in Barnes' study was not spontaneous, children's *application* of the model when representing unmentioned paths was. Unlike the children in Barnes et al's (2014) study, the children completing the character movement task did not have a physical model available to them. The character movement task was therefore more demanding, but also more representative of real-life scenarios, as children are not typically given a map or model of a story's setting. The paradigm used in Barnes et al. (2014) could be seen as similar, perhaps, to the situation of seeing a film adaptation of a book before reading the book. In both cases, one has the advantage of having some form of visuospatial representation of the world in which the story takes place, which may support comprehension when one begins reading or listening to a story.

Within our study, we found a marginally significant difference in children's tendency to enact the two different inferred movements. Children enacted the movement corresponding to the sentence "*He went to his mom's room to ask her if she knew where his backpack was*" 32% of the time, compared to "*Jamie picked up his backpack off the playroom floor*", which was enacted 25% of the time. Although marginal, this difference suggests that subtle differences in cues in narratives may affect what information is represented. One possible explanation for this



difference is that an additional inference had to be made in the latter sentence that the character was moving to a new location at all. Another possibility, suggested to us by an anonymous reviewer, is that children were more likely to enact the former sentence because it included an explicit mention of the character's goal. In support of this view, children were also more likely to enact the non-inferred movement that included an explicit goal ("*Jamie went downstairs to look for some sunscreen*", 71%) versus the sentence that did not ("*Jamie went upstairs to his mom's room*", 66%).

Research by Fecica and O'Neill (2010) suggests that children are sensitive to the dynamic interplay between characters' goals and movement. They found that 4- and 5-year-old children processed sentences more quickly when a character was moving towards a destination she was eager to get to, compared to a destination she was dreading going to.

In the first study to investigate children's situation models in cases where their knowledge state conflicted with that of the character, Ronfard and Harris (2014) found that children's sensitivity to a character's movement towards a goal came at a cost to their comprehension. Specifically, they investigated the thoughts and emotions children attributed to Little Red Riding Hood as she approached her grandmother's house, where, unbeknownst to her, a wolf was waiting. Children consistently denied that the protagonist knew about the presence of the wolf, but incorrectly attributed emotions of fear to the character, and did so increasingly as she got closer to her grandmother's house. These findings were replicated with an unfamiliar character who did not know his friends were waiting to surprise him at his house. Whereas Fecica and O'Neill (2010) found that children's representations of a character's motivational state can modulate their representations of her movement toward a goal, Ronfard and Harris (2014) found that children's representations of a character's movement toward a goal can

detrimentally affect their representations of her emotional state, at least in cases when children's knowledge states conflict with that of the character. Importantly, Ronfard and Harris's (2014) study presented children with a physical model of the story world, whereas Fecica and O'Neill (2010) did not. A possibility is that the saliency of the physical model of Little Red Riding Hood's movement made it more difficult for children to inhibit their knowledge as she neared her grandmother's house.

Together with our findings, this previous work suggests that children represent character movement in a dynamic way in the preschool years, but may not be able to infer unmentioned movements until middle childhood. The finding that children in our study enacted inferred movements about 25% of the time suggests that the ability to construct spatial representations that constrain and predict characters' movements is an emerging ability in 7- and 8-year-old children.

Note that tracking Jamie's location was not crucial for comprehension within the particular passage presented to children. As such, the character movement task may have *underestimated* children's propensity to construct spatial representations during narrative processing. Tracking characters' movements and location may be crucial for comprehension in other narratives. Findings with adults suggest that they may only construct detailed spatial representations within narratives when doing so is causally relevant (Jahn, 2004). If a narrative had been provided to children in which space had more causal relevance, we might have observed more children carrying out the stair movements.

### **The relationship between enactment and comprehension**

Despite the finding that children demonstrated stair movements on inferred sentences only 25% of the time overall, this ability was nevertheless significantly predictive of their

narrative comprehension abilities. This finding corroborates those of Barnes and colleagues (2014), although they used a different experimental paradigm, as well as a different standardized comprehension measure that relied upon a different processing medium (reading vs. listening). In their study, children's ability to infer a character's movement along an unmentioned path was predictive of their reading comprehension abilities. The ability to construct and update a dynamic spatial situation model, measured in the Barnes et al. study, and in the present study, therefore appears to be integral to the comprehension process. These findings raise the intriguing possibility that the opportunity (in Barnes et al.'s study) or ability (in the present study) to construct a spatial representation of the story world provided a framework to children for representing the events that took place within the story. Thus, it seems that this finding connecting spatial situation model construction and comprehension may be robust and generalizable.

These findings further contribute to our understanding of children's narrative comprehension by demonstrating that the ability to spontaneously construct a spatial representation of the narrative by tracking a character's location, based on information information that can be inferred from a text, is predictive of comprehension abilities. Because the task requires only basic resources, it is possible that, after further validation and replication, it could be used in classrooms as a measure or indication of children's situation model construction and updating, which our results and those of Barnes and colleagues (2014) suggest are an important component of skilled comprehension.

### **Limitations and future directions**

There are a few limitations to the present study that are worth noting. First, the character movement task relied on only two inferred enactment movements, which involved the character

moving up and down stairs. While we believe this movement was relatable to children and provided a clear movement to observe and code non-problematically, future investigations could include a greater number and variety of movements that also meet these requirements. Second, the present study made use of a single narrative in order to enable an individual differences approach with a large number of participants. Future work could investigate the replicability of these findings using different narratives and different types of movements. Third, it may have been the case that some of the children in the study were mentally representing the character's movement up and down the stairs, but were not physically manipulating the figurine in a way that reflected this. Future investigations could explore whether other measures, such as reaction time or eye-tracking tasks, might be able to reveal movement in a situation model by a listener.

Another possible question for future research is whether giving children a map, model, or image of a story's setting ahead of time supports comprehension. A study with 7- to 11-year-olds found that providing children with informative illustrations supported inference-making during comprehension (Pike, Barnes, & Barron, 2010). A training study with poor comprehenders found that providing children with a physical model of the setting, characters, and objects in a story that they could manipulate helped to bolster their comprehension (Glenberg, Gutierrez, Levin, Japuntich, & Kaschak, 2004). The latter findings, which support an embodied view of language processing, suggest that providing children who may not spontaneously visualize and mentally simulate aspects of narratives with external supports can help them to eventually be able to do so. Together, our findings, along with those of Barnes et al (2014) and Glenberg et al (2004), suggest that the ability to construct spatial situation models and draw necessary inferences may be an important ability underlying comprehension.

## References

- Barnes, M. A., Raghobar, K. P., Faulkner, H., & Denton, C. A. (2014). The construction of visual-spatial situation models in children's reading and their relation to reading comprehension. *Journal of Experimental Child Psychology, 119*, 101-111.  
doi:10.1016/j.jecp.2013.10.011
- Berenhaus, M., Oakhill, J., & Rusted, J. (2015). When kids act out: a comparison of embodied methods to improve children's memory for a story. *Journal of Research in Reading, 38*(4), 331-343. doi: 10.1111/1467-9817.12039
- Bruner, J. (1986). *Actual minds, possible worlds*. Cambridge: Harvard University Press.
- Cain, K., Oakhill, J., & Bryant, P. (2004). Children's Reading Comprehension Ability: Concurrent Prediction by Working Memory, Verbal Ability, and Component Skills. *Journal of Educational Psychology, 96*(1), 31-42. doi:10.1037/0022-0663.96.1.31
- Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning & Verbal Behavior, 19*(4), 450-466.  
doi:10.1016/S0022-5371(80)90312-6
- de Vega, M. (1995). Backward updating of mental models during continuous reading of narratives. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 21*, 373-385. doi:10.1037/0278-7393.21.2.373
- Fecica, A. M., & O'Neill, D. K. (2010). A step at a time: Preliterate children's simulation of narrative movement during story comprehension. *Cognition, 116*(3), 368-381.  
doi:10.1016/j.cognition.2010.05.014

## CHILDREN'S ENACTMENT OF CHARACTERS' MOVEMENTS

- Glenberg, A. M., Gutierrez, T., Levin, J. R., Japuntich, S., & Kaschak, M. P. (2004). Activity and Imagined Activity Can Enhance Young Children's Reading Comprehension. *Journal of Educational Psychology, 96*, 424-436. doi:10.1037/0022-0663.96.3.424
- Jahn, G. (2004). Three Turtles in Danger: Spontaneous Construction of Causally Relevant Spatial Situation Models. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 30*(5), 969-987. doi:10.1037/0278-7393.30.5.969
- Johnson-Laird, P. N. (1983). *Mental models: Towards a cognitive science of language, inference, and consciousness*. Cambridge: Harvard University Press.
- Kintsch, W., & Van Dijk, T. A. (1983). *Strategies of discourse comprehension*. New York: Academic Press.
- Morrow, D. G., Greenspan, S. L., & Bower, G. H. (1987). Accessibility and situation models in narrative comprehension. *Journal of Memory and Language, 26*(2), 165-187. doi:10.1016/0749-596X(87)90122-7
- Neale, M. D. (1997). *Neale Analysis of Reading Ability – Revised*. Windsor: NFER-Nelson.
- Nyhout, A., & O'Neill, D. K. (2013). Constructing Spatial Representations from Narratives and Non-Narrative Descriptions: Evidence from 7-year-olds. In *OASISs-OpenAccess Series in Informatics* (Vol. 32). Schloss Dagstuhl-Leibniz-Zentrum fuer Informatik.
- O'Brien, E. J., & Albrecht, J. E. (1992). Comprehension strategies in the development of a mental model. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 18*, 777-784. doi:10.1037/0278-7393.18.4.777
- O'Neill, D. K., & Shultis, R. M. (2007). The emergence of the ability to track a character's mental perspective in narrative. *Developmental Psychology, 43*(4), 1032-1037. doi:10.1037/0012-1649.43.4.1032

## CHILDREN'S ENACTMENT OF CHARACTERS' MOVEMENTS

- Pike, M. M., Barnes, M. A., & Barron, R. W. (2010). The role of illustrations in children's inferential comprehension. *Journal of Experimental Child Psychology, 105*(3), 243-255. doi: 10.1016/j.jecp.2009.10.006.
- Radvansky, G. A., & Copeland, D. E. (2010). Reading times and the detection of event shift processing. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 36*, 210–216. doi:10.1037/a0017258
- Radvansky, G. A., Zwaan, R. A., Curiel, J. M., & Copeland, D. E. (2001). Situation models and aging. *Psychology and Aging, 16*(1), 145.
- Rall, J., & Harris, P. L. (2000). In Cinderella's slippers? Story comprehension from the protagonist's point of view. *Developmental Psychology, 36*(2), 202-208. doi:10.1037/0012-1649.36.2.202
- Rapp, D. N., & Taylor, H. A. (2004). Interactive dimensions in the construction of mental representations for text. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 30*(5), 988-1001. doi:10.1037/0278-7393.30.5.988
- Ronfard, S., & Harris, P. L. (2014). When will Little Red Riding Hood become scared? Children's attribution of mental states to a story character. *Developmental Psychology, 50*, 283-292. doi: <http://dx.doi.org/10.1037/a0032970>
- Smith, E. R., & O'Brien, E. J. (2012). Tracking spatial information during reading: A cue-based process. *Memory & Cognition, 40*, 791-801. doi: 10.3758/s13421-012-0190-8
- Sundermeier, B. A., van den Broek, P., & Zwaan, R. A. (2005). Causal coherence and the availability of locations and objects during narrative comprehension. *Memory & Cognition, 33*, 462–470. doi: 10.3758/BF03193063

## CHILDREN'S ENACTMENT OF CHARACTERS' MOVEMENTS

Swanson, H. L., Cochran, K. F., & Ewers, C. A. (1989). Working memory in skilled and less skilled readers. *Journal of Abnormal Child Psychology*, *17*(2), 145-156.

doi:10.1007/BF00913790

Woodcock, R. W., McGrew, K. S., & Mather, N. (2001). Woodcock-Johnson III. Itasca, IL: Riverside Publishing.

Ziegler, F.V., & Acquah, D.K. (2013). Stepping into someone else's shoes: Children create mental models from the protagonist's point of view. *European Journal of Developmental Psychology*, *10*(5), 546-562. doi: 10.1080/17405629.2012.744689

Ziegler, F., Mitchell, P., & Currie, G. (2005). How does narrative cue children's perspective taking?. *Developmental Psychology*, *41*(1), 115. doi: 10.1037/0012-1649.41.1.115

Zwaan, R. A., & Radvansky, G. A. (1998). Situation models in language comprehension and memory. *Psychological Bulletin*, *123*(2), 162-185. doi:10.1037/0033-2909.123.2.162

Zwaan, R. A., & van Oostendorp, H. (1993). Do readers construct spatial representations in naturalistic story comprehension? *Discourse Processes*, *16*(1-2), 125-143.

doi:10.1080/01638539309544832

Zwaan, R.A. & van Oostendorp, H. (1994). Spatial information and naturalistic story comprehension. In H. van Oostendorp & R.A. Zwaan (eds.), *Naturalistic text comprehension* (pp. 97- 114). Norwood, NJ: Ablex Publishing Corporation.



CHILDREN'S ENACTMENT OF CHARACTERS' MOVEMENTS

*Table 1. Number of children enacting each number of movements*

Number of Movements	Instructed (/2)	Non- instructed (/2)	Total (/4)
0	18	66	17
1	31	20	24
2	57	20	33
3			13
4			19

CHILDREN'S ENACTMENT OF CHARACTERS' MOVEMENTS

Table 2. Correlation (Pearson's *r*) between variables included in regression model

	Non-inferred Movements	Inferred Movements	Narrative Comp	Oral Comp	Vocab	Working Memory	Age
Total Movements	0.84**	0.85**	0.26*	0.07	0.10	0.03	-0.03
Non-inferred Movements		0.43**	0.15	0.08	0.05	0.10	-0.04
Inferred Movements			0.26*	0.04	0.12	-0.04	-0.01
Narrative Comprehension				0.60**	0.51**	0.19*	0.29**
Oral Comprehension					0.54**	0.26**	0.31**
Vocabulary						0.25*	0.12
Working Memory							-0.03
Age							

\*\* Correlation is significant at the 0.01 level (2-tailed).

\* Correlation is significant at the 0.05 level (2-tailed).

CHILDREN'S ENACTMENT OF CHARACTERS' MOVEMENTS

Table 3. Results of a hierarchical regression with narrative comprehension (adapted NARA) as the dependent measure. A third model, in which only non-inferred and inferred movements were entered as predictors is also displayed. Significant predictors are shown in bold text.

	Variable	B	SE B	$\beta$	<i>t</i>	<i>p</i>
Model 1	Age	0.85	0.49	0.14	1.73	.088
	<b>Oral Comprehension</b>	0.35	0.08	0.40	4.20	<.001
	<b>Vocabulary</b>	0.33	0.11	0.27	3.07	.003
	Working Memory	0.02	0.06	0.02	0.29	.777
Model 2	Age	0.89	0.48	0.14	1.85	.067
	<b>Oral Comprehension</b>	0.35	0.08	0.40	4.31	<.001
	<b>Vocabulary</b>	0.30	0.11	0.25	2.81	.006
	Working Memory	0.03	0.06	0.04	0.45	.657
	Non-inferred Movement	0.11	0.35	0.03	0.31	.760
	<b>Inferred Movement</b>	0.78	0.33	0.19	2.35	.021
Model 3	Non-inferred Movement	0.23	0.44	0.05	0.52	.607
	<b>Inferred Movement</b>	0.90	0.43	0.22	2.11	.038

Dependent variable: narrative comprehension (adapted NARA)

Appendix A

**Jamie Goes to Summer Camp**

1. Jamie woke up one morning and was really excited to start his first day of adventure camp.
2. It was time to get ready.
3. In his bedroom, Jamie changed into a pair of shorts and a blue t-shirt.
4. He put on his socks and thought, "I can't wait for summer camp!"
5. Jamie went into his mom's room to say "good morning".
6. Then, Jamie walked into the bathroom.
7. He brushed his teeth and washed his face.
- 8. Jamie went downstairs to look for some sunscreen.** (Non-inferred movement)
9. He looked in the kitchen.
10. He looked in the playroom.
11. And he looked in the living room.
12. There it was, on the coffee table.
13. Jamie just needed to pack his backpack for camp now.
- 14. He went to his mom's room to ask her if she knew where his backpack was.** (Inferred movement)
15. His mom was sitting on her bed reading.
16. "Your backpack is in the playroom, Jamie," said mom.
- 17. Jamie picked up his backpack off the playroom floor.** (Inferred movement)
18. He was almost ready for camp!
19. Jamie still needed to get his lunch and some water.
20. Jamie went into the kitchen.
21. He took his lunch and a water bottle out of the fridge and put them in his backpack.

## CHILDREN'S ENACTMENT OF CHARACTERS' MOVEMENTS

22. Jamie went to the front door.

23. "Almost ready" Jamie thought.

24. He strapped on his backpack and put his green hat on.

**25. Jamie went upstairs to his mom's room.** (Non-inferred movement)

26. "I'm ready to go, Mom!" Jamie said.

27. Jamie set off with his mom for his very first day of summer camp.

Note: critical sentences are in bold.