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A step at a time: Preliterate children's simulation of narrative movement during story comprehension

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ABSTRACT

A growing body of work suggests that narrative comprehension involves the simulation of the described events and actions (e.g., Barsalou, 2008; Matlock, 2004). Preliterate children's ability to simulate a narrative character's movements is explored here in three studies. Children's simulations of a character's movements were found to be constrained by their expectation of the *duration* of the described activities (i.e., walking vs. driving) and by their expectations about the motivating influence of certain *psychological factors* (i.e., character being eager or not eager to get to a location). These findings reveal an ability among preliterate children to create impressively rich and dynamic mental representations of narrative events and address, with a novel methodology, an identified need for greater exploration of precursors to narrative comprehension.

1. Introduction

The ability to create and comprehend narratives is a remarkable feature of the human mind. While reading, readers explore the perspective of another person, place, or time (e.g., Gerrig, 1993; Wolf, 2007). Research reveals that readers and listeners often behave as if they are embedded in the narrative situation, tracking and adopting a character's spatial, temporal, and psychological perspective (e.g., Black, Turner, & Bower, 1979; Bower & Morrow, 1990; Gernsbacher, Goldsmith, & Robertson, 1992; Graesser, Singer, & Trabasso, 1994; Morrow, Bower, & Greenspan, 1989; O'Neill & Shultis, 2007; Rall & Harris, 2000; Tapiero, 2007; Trabasso & Suh, 1993; Ziegler, Mitchell, & Currie, 2005; Zwaan, 1999; Özyürek & Trabasso, 1997). Such findings indicate that, in addition to a representation of the surface structure of narratives, narrative comprehension also involves the creation of a mental representation of the described situation, known as a situation model (e.g., Johnson-Laird, 1983; Kintsch, 1998; Zwaan & Radvansky, 1998). The creation of a situation model during comprehension is an ongoing process that involves the integration of a readers' background knowledge with the information contained in the text. Studies indicate that adults' situation models are quite detailed and contain information about the time, space, entities, intentionality, and causal relations of the events and actions described in a narrative (e.g., Zwaan, 1999; Zwaan & Radvansky, 1998).

A growing number of behavioral and neuropsychological studies have presented evidence in support of an *embodied* account of situation models. Such embodied accounts of situation models fit within the larger framework of embodied cognition wherein "high-level cognitive processes (e.g., language, mathematics) are grounded in bodily mechanisms of perception, action, and affect (Barsalou, 1999, 2008; Semin & Smith, 2008)" (Glenberg, Goldberg, & Zhu, 2009, p. 3). This has led many to question a strictly amodal account of comprehension, which rests on the premise that "language comprehension relies on the interdependencies of words" (Louwerse & Jeuniaux, 2008, p. 309; for reviews of these alternative accounts see Barsalou, 1999, 2008; Zwaan, 2004). The general conclusions drawn from the results of

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these studies is that "language comprehension requires activation of our experiences with the world" (Louwerse & Jeuniaux, 2008, p. 310) and that during comprehension readers mentally simulate the perceptual, motor, and affective content of narratives (Barsalou, 2008; Brunyé, Ditman, Mahoney, Augustyn, & Taylor, 2009; Fischer & Zwaan, 2008; Glenberg, 2007; Havas, Glenberg, & Rinck, 2007; Speer, Reynolds, Swallow, & Zacks, 2009; Zwaan, 2004). Consequently, it has also been argued that, "...a simulation should share certain 'physical' characteristics with its real-world counterpart" and that "any transformation the referent undergoes should cause an analogous transformation in the simulation" (Stanfield & Zwaan, 2001, p. 153; see also Barsalou, 1999).

And indeed, numerous neuroimaging and behavioral studies have provided evidence consistent with an embodied account, suggesting that during comprehension readers often activate the perceptual and motor information described in a text (e.g., Brunyé et al., 2009; Fischer & Zwaan, 2008; Glenberg & Kaschak, 2002; Matlock, 2004; Pecher & Zwaan, 2005; Pulvermüller, 2005; Speer et al., 2009; Stanfield & Zwaan, 2001; Zwaan, 2004; Zwaan & Madden, 2005; Zwaan, Stanfield, & Yaxley, 2002). For example, reading action words (e.g., kick, run) has been found to activate brain regions associated with the performance of those actions (Pulvermüller, 2005). Such findings have not been limited to the comprehension of single word lists but have also been observed during the comprehension of longer stretches of text such as stories. Speer et al. (2009) investigated the activity of different brain regions involved in the creation of situation models and revealed increased activation in brain regions involved in the manual manipulation of objects, the navigation of spatial environments, and the processing of goal-oriented human when those aspects of the narrated situation changed. For example, precentral and parietal areas associated with grasping hand movements increased in activation when the narrative situation involved a change in a character's interaction with an object. These findings were interpreted by Speer et al. (2009) to suggest that the brain regions involved in the performance, imagination, and observation of real-world activities are also involved in story comprehension. Overall, the results of neuroimaging studies suggest that the process of comprehending narratives may involve the use of perceptual and motor representations to simulate the events and actions described in a narrative.

Behavioral studies also support the view that simulation plays a critical role in narrative comprehension (e.g., Glenberg & Kaschak, 2002; Zwaan et al., 2002; see also Barsalou, 2008; Zwaan, 1999 for reviews). Studies utilizing a reaction-time methodology indicate that adult readers simulate the perceptual and visual information described in a text (e.g., Stanfield & Zwaan, 2001; Zwaan et al., 2002). For example, after reading a sentence describing an action (e.g., The ranger saw an eagle in the sky), people were faster to recognize a picture that was consistent with the described event (e.g., picture of eagle with outstretched wings) than a picture that was inconsistent with the described event (e.g., picture of eagle with folded wings). Other studies indicate that adult readers are faster at making movements that are consistent with the action described in a text than movements that are inconsistent with the action described (Glenberg & Kaschak, 2002). Findings also suggest that readers simulate the duration of movements described in a story. In Matlock (2004), readers took longer to read the sentence "Road 49 crosses the desert" when they were told earlier that the desert was 400 miles in diameter than when they were told the desert was only 30 miles in diameter. Together, the results of both behavioral and neuroimaging studies suggest that narrative comprehension, and especially the creation of situation models, involves the simulation of linguistically described events.

Important questions about the developmental nature of the ability to simulate narrative events have not been the focus of investigation. Indeed, little is known about the narrative precursors of reading comprehension, and particularly children's comprehension of oral stories. It has been argued that studies of antecedents of reading comprehension are very much needed if we are to gain a fuller understanding of how literacy and narrative comprehension skills develop (Lynch et al., 2008). More specifically, Skarakis-Doyle and Dempsey (2008) have argued that an exploration of preschool-aged children's mental representations of stories is merited given that, "many of the foundational abilities that contribute to children's comprehension of stories emerge in their oral language comprehension in advance of their learning to read" (p. 131). Thus, while an investigation of young children's ability to simulate narrative events is warranted in its own right, exploring this particular aspect of young children's narrative comprehension will address a hitherto relatively unexplored aspect of narrative competence of potential importance to both narrative development and precursors to literacy.

A comprehensive model of narrative comprehension in children does not exist. But several aspects of young children's narrative comprehension have been quite extensively studied, including story structure understanding, inference making and comprehension monitoring, generally in children older than age 4 (for reviews see Lynch et al., 2008; Perfetti, Landi, & Oakhill, 2005). The study of young children's situation models is a more recent area of study, with only three studies to date exploring this aspect of children's narrative comprehension (O'Neill & Shultis, 2007; Rall & Harris, 2000; Ziegler et al., 2005). Comprehension ability has also received more separate study from the vantage point of children's literacy development and such models have been concentrated on identifying critical components of reading ability and their developmental emergence (e.g., decoding, phonological processing, inference making). The ability to simulate narrative events has not been a focus of such models either. However, some evidence from studies conducted by Glenberg and colleagues with novice readers and school-aged children who are poor readers has led to the suggestion that the process of mental model creation may not be transparent for some early readers (Glenberg, Brown, & Levin, 2007, p. 390; Glenberg et al., 2009; Marley, Levin, & Glenberg, 2007).

The three studies to date exploring young children's situation models in narrative comprehension (O'Neill & Shultis, 2007; Rall & Harris, 2000; Ziegler et al., 2005) have demonstrated that preschoolers' situation models of stories contain information about a character's location and mental goals and that preschoolers adopt the spatial (Rall & Harris, 2000; Ziegler et al., 2005) and mental perspective of the main character (O'Neill & Shultis, 2007) by about 4 years of age. In Rall and Harris (2000), and also Ziegler et al.'s (2005) studies, children's ability to track a character's spatial perspective was explored in a fairly *static* manner. For example, Rall and Harris (2000) asked 3- and 4-year-old children to recall target sentences in stories that included deictic verbs of motion (i.e., perspective-dependent verb forms) such as, "*Cinderella was sitting on the chair by the fireplace, dreaming about the ball. Then her fairy godmother came (went) into the cottage*." They found that, like adults, children's accuracy in recalling the targeted deictic verbs of motion suffered when the verb of motion was inconsistent with the protagonist's spatial perspective (e.g., went), rather than when the verb of motion was consistent with the protagonist's perspective (e.g., came). Although, this study demonstrated that preschoolers do indeed track a character's spatial perspective, it did not explore the more dynamic temporal component of a character's movement. Indeed, as stories are essentially series of events happening in space and time (Tversky, 2004; Wilson, 2003), it is even more informative for narrative comprehension to consider whether children track and simulate the *spatial–temporal* aspects of narratives – for example, the duration of actions performed by a character.

Three new studies were designed to explore the spatial–temporal aspects of young children's situation models of narratives by investigating whether and how children's expectations about the duration of certain activities (e.g., walking vs. driving) influences their simulation of narrative action. Research suggests that adult readers' expectations exert influence over a variety of narrative comprehension processes including simulations (e.g., Anderson, Garrod, & Sanford, 1983; Rapp, Klug, & Taylor, 2006; Rapp & Taylor, 2004; Zwaan, 1994). For example, Rapp et al. (2006) explored the influence of readers' expectations on the well established finding that readers track a character's movements and take longer to identify objects that are located further from a character's current location than objects that are located near the character (Morrow, Greenspan, & Bower, 1987; Morrow et al., 1989). Rapp et al. (2006) found that when the events of a story did not clearly specify how a character moved from one location to another, and several alternative paths were available, readers no longer appeared to process text in a manner consistent with this spatial distance effect. The authors argue that expectations, which are often based on personal experiences, enable readers to anticipate how a narrative will unfold. And, in this case, the alternative paths made prediction of a character's path unpredictable, thus leading to the elimination of the spatial distance effect. Such findings highlight the importance of taking into consideration readers' expectations when investigating narrative comprehension and simulations of narrative events.

In our first study, we explored whether young children's expectations about the duration of particular physical activities (i.e., walking vs. driving) would influence their simulation of the speed of a narrative character's movements. That is, as will be described further in the method section for Study 1, would children's processing times for sentences heard describing a child character walking be slower than their processing times for sentences heard describing that same character being driven?

Study 2 explored whether children's expectations about the influence of certain motivating psychological factors (i.e., eagerness to get to a particular location) might also influence children's simulations of the speed of a character's actions. In other words, would children's processing times be faster for sentences describing a child character "getting ready" (e.g., getting dressed) for an activity that he/she thinks is "really great" as opposed to "really horrible"?

Study 3 explored the combined effect of children's expectations about the duration of particular physical activities, specifically walking and driving, with the motivating effect of eagerness. Because previous studies suggest that the ability to create detailed mental representations of narratives begins to emerge in preschoolers (O'Neill & Shultis, 2007; Rall & Harris, 2000; Ziegler et al., 2005), the following three studies of children's ability to simulate a character's movement focused on 3- to 5-year-olds.

2. Study 1

Study 1 explored whether young children's expectations about the duration of particular physical activities (i.e., walking vs. driving) would influence their simulations of the speed of a character's movements. To answer this question, we created stories that contained a manipulation of the speed of a character's movement from one location to another; namely, two ordinary motor activities familiar to young children: walking and driving. We reasoned that if children's simulations of narratives are constrained by their expectations and personal experiences of the duration of these two activities, then a character who is walking would be expected to pass by scenes along the way more slowly than a character who is being driven. And, in keeping with previously observed reading time methodologies used to study narrative comprehension in adults (Matlock, 2004), our corresponding prediction was that children would demonstrate longer processing times for the events described as being observed by a character walking as opposed to being driven.

To test this prediction in young children, we modified a self-paced reading task typically used to investigate narrative comprehension processes in adults (e.g., Zwaan & Singer, 2003). In the adult version of the task, readers read a sentence displayed on a computer screen and press a computer key to be presented with the next sentence in the text, providing researchers with an estimate of the amount of time readers take to process each sentence. Because, most 3- and 4-year-olds cannot read, the children in our study listened to a pre-recorded story presented via computer speakers. The story was presented one sentence at a time and the children pressed a mouse button to hear each new sentence of the story. This methodology enabled us to measure the amount of time children took to process each sentence of the story (*processing time or PT*). (See Method section for more details regarding our PT measure.) No other study has utilized this type of methodology to investigate young children's story comprehension processes.

The story described a small child, Jamie, visiting aunt Alice's house (see Appendix A). In one part of the story, Jamie was described as *walking* to aunt Alice's house, and in another part of the story as being *driven* to aunt Alice's house (i.e., Jamie's mother said, "You know what Jamie? This time, let's walk/drive to aunt Alice's"). Along the way to aunt Alice's house, Jamie was described as viewing a series of four different events (e.g., dogs in a park, some children playing baseball). Children heard a different, but similar, set of four events for each of the two manipulations of the character's movement (drive/walk). We predicted that, if preschoolers simulate a character's movement while listening to a story, then they should proceed through the description of the four events Jamie sees along the way to aunt Alice's house more quickly (i.e., faster PT) when Jamie is being driven past them as opposed to walking past them. That is, we reasoned that if children's simulations of a character's movements and experiences are influenced by their expectations of the duration of these movements - for example, it takes less time to reach a particular location when one is riding in a car as opposed to walking – then these expectations should be reflected in a predictable manner in the relative duration of children's processing times (PT).

2.1. Method

2.1.1. Participants

The participants were 48 native speakers of English with no reported history of speech or hearing difficulties: 24 younger preschoolers (12 boys and 12 girls, mean age = 47 months, range = 41–53), 24 older preschoolers (12 boys and 12 girls, mean age = 57 months, range = 55–65) drawn from a university child laboratory database. An additional seven children were tested but excluded from the dataset because of fussiness ($n = 3$) or unwillingness to listen to the story ($n = 4$).

2.1.2. Procedure and materials

Children were seated at a small table beside an experimenter. Two different tasks were administered to each child. Each child first received the story listening task, followed by four subtests of a standardized measure of language development (*Clinical Evaluation of Language Fundamentals – Preschool*, Second Edition (CELF-P2); Wiig, Secord, & Semel, 2004).

2.1.2.1. Story listening task. The main focus of the study was children's performance on the story listening task. Each child listened to two pre-recorded stories (one practice and one experimental story) presented via computer speakers. The stories were initially recorded, using Audacity recording software (2007), one sentence at a time, in random order and in a neutral tone, by an adult female research assistant, not otherwise affiliated with the study. Children heard one sentence of the story at a time and pressed a mouse button to hear the next sentence of the story. The time from the *end* of each sentence to the child's next button press (i.e., processing time or PTs) was measured and logged by a Vault PC Series computer. Both story presentation and processing time data collection were controlled by E-prime software (Schneider, Eschmann, & Zuccolotto, 2002).

At the start of each session, a drawing depicting Jamie, a friendly looking preschool child (a boy for male participants and a girl for female participants), was placed in front of the children. Children were introduced to the story listening procedure by listening to a 15-sentence practice story. Children were encouraged to listen carefully to the story by being told that they would be asked four questions later about the story and would receive a sticker for every correct answer.

The experimental story described Jamie visiting aunt Alice's house and contained two manipulations of the character's movement. The story consisted of seven components (Appendix A). Component 1 introduced the setting of the story. The first manipulation of the character's movement occurred in Component 2. Children heard Jamie's mom say "You know what Jamie? This time, let's walk/drive to aunt Alice's". In Component 3, immediately following this movement manipulation, children heard one of the two key focal four-sentence long descriptions of the scenery Jamie saw along the way to the aunt's house (e.g., kids playing baseball, birds flying around someone's yard). Component 4 described Jamie's adventures at aunt Alice's house, return home, as well as the reason for returning to aunt Alice's house (i.e., forgotten cell phone). Component 5 contained the second reverse manipulation of the character's movement to aunt Alice's house. In Component 6, children heard the second of the two key focal four-sentence long descriptions of the scenery Jamie saw along the way back to aunt Alice's house similar to that of Component 3. Component 7 concluded the story. To assess children's ability to track a character's spatial–temporal perspective, we compared children's PTs collected during the key focal descriptions of the scenery Jamie saw along the way to aunt Alice's house (i.e., Components 3 and 6) in the walk condition to the corresponding set of PTs in the drive condition. Each child heard the story once. The presentation order of Components 2 and 5 (movement manipulation) and 3 and 6 (descriptions of scenery) were fully counterbalanced across children. Following the story, children were asked four story comprehension questions: Who did Jamie visit?/What did Jamie do at aunt Alice's?/How did Jamie get there the first/s time? Children received one point for every correct answer.

2.1.2.2. Language measures. Children were administered the three core language subtests (Sentence Structure, Word Structure, and Expressive Vocabulary) of the CELF-P2 as well as the Recalling Sentences in Context (RSC) supplementary subtest which evaluates a child's ability to repeat sentences presented in the context of a story without changing the wording of the sentence. We selected the CELF-P2 because it can be administered fairly quickly to young children and is commonly used to provide a broad overview of children's general language ability.

Table 1
Children's PTs in Study 1 collected during the four scenery sentences[a] presented to children in the walk and drive conditions ($N = 48$).

Scenery sentences	Processing times (ms)		Difference (SE)	p-Value
	Condition			
	Walk	Drive		
1	1083	911	172 (126)	.18
2	1274	1001	273 (124)	.03
3	975	543	432 (170)	.01
4	922	727	195 (101)	.06

[a] See Appendix A, example of Study 1 story, Components 3 and 6 (Sentences 7–10 and 26–29).

2.2. Results and discussion

Thirty-six out of 46 children[1] answered at least three of the four story comprehension questions correctly, suggesting that overall the children had complied with instructions and listened carefully to the story.[2] The data analysis focused on a comparison of the mean of the four PTs collected, for each child, during the four-sentence description of the scenery Jamie saw along the way to aunt Alice's house in the *walk* portion of the story with the mean of the four PTs collected for during the four-sentence description of scenery in the *drive* portion of the story (i.e., Components 3 and 6; eight PTs in total). As is standard procedure in studies utilizing reading time methodology, an outlier analysis was performed on children's processing times. We adopted a conservative approach and removed any PTs that were four standard deviations from each participant's condition mean, resulting in the exclusion of 2.2% of the total processing time data. Participants' mean PTs were then submitted to a speed of movement (walk vs. drive) × age (younger vs. older preschoolers) × story order (walk/drive vs. drive/walk) × sex (girl vs. boy) repeated measures mixed model ANOVA with speed of movement condition as the within-subjects factor. The analysis revealed no significant main effects of age, $F(1, 40) = 2.3$, $MSE = 606{,}454$, $p = .14$, $\eta^2 = .06$; story order, $F(1, 40) = .51$, $MSE = 606{,}454$, $p = .48$, $\eta^2 = .01$; or sex, $F(1, 40) = .43$, $MSE = 606{,}454$, $p = .52$, $\eta^2 = .01$. None of these variables interacted with speed of movement condition, all $ps > .1$.

As predicted, children's mean PTs were significantly faster when Jamie was driven ($M = 796$ ms, SE = 61 ms) vs. when Jamie walked to aunt Alice's house ($M = 1064$ ms, SE = 111 ms), resulting in a mean difference of 268 ms between conditions, $F(1, 40) = 9.7$, $MSE = 173{,}075$, $p = .003$, $\eta^2 = .2$. Children's mean PTs were faster on all four scenery sentences (i.e., Components 3 and 6) in the drive condition than in the walk condition. Table 1 provides the results of more detailed sentence-by-sentence paired-samples t-test analyses of the speed of movement effect.

Moreover, this speed of movement effect was highly specific and confined only to the sentences in Components 3 and 6 pertaining to the description of the scenery the character Jamie observed along the way to aunt Alice's house. That is, it was not observed for the movement manipulation sentence that immediately preceded the scenery description, even though the movement word 'walk' or 'drive' was explicitly stated (i.e., "You know what Jamie? This time, let's *walk/drive* to aunt Alice's"; Components 2 and 5), $t(47) = .17$, $p = .87$, $M_{\text{Walk}} = 1373$ ms, $M_{\text{Drive}} = 1402$ ms. It was also not observed for each of the two sentences immediately following each of the two key scenery description components (i.e., Sentence 11 or 30, $t(47) = .88$, $p = .39$, M_{Walk} (i.e., following walk condition scenery sentences) = 1070 ms, M_{Drive} (i.e., following drive condition scenery sentences) = 1209 ms; or Sentence 12 or 31, $t(47) = .58$, $p = .56$, M_{Walk} condition = 1292 ms, M_{Drive} = 1144 ms. In addition, no significant effect of speed of movement was found for the full remaining portions of the story (i.e., Components 4 and 7), $t(47) = 1.4$, $p = .18$, M_{Walk} = 1265 ms, M_{Drive} = 1380 ms. That is the speed of movement effect was confined only to the focal Components 3 and 6.

Correlation analyses did not reveal a significant relation between children's performance on the story listening task (as assessed by processing time difference scores between the walk and drive condition) and children's performance on any of the CELF-P2 subtests (all p's > .1).

In interpreting the results of this study, the reader is reminded that the scenery description sentences were counterbalanced across the walk/drive condition and across participants, thus any differences with regard to the content of the scenery descriptions or presentation order cannot account for the results. Overall, these findings support the hypothesis that children simulate a character's movement during story comprehension and that these simulations are constrained by their knowledge and expectations of the duration of certain motor activities, such as walking and driving.

3. Study 2

Study 2 was designed to continue our exploration of the manner in which children's expectations and prior knowledge influence their simulations of the duration of a character's movement. Older preschoolers' sophisticated understanding of other people's mental states is well documented (e.g., Perner, 1991; Wellman, 2004) and previous studies have revealed that 4-year-olds track and adopt a character's mental goal perspective (O'Neill & Shultis, 2007). In Study 2, we explored the impact of a far more sophisticated type of expectation on children's simulations of a character's movement, namely, the *motivating influence of certain psychological states such as eagerness*.

To illustrate what we mean by eagerness, consider the following passage from *The Secret Garden* (Burnett, 1909/1993, p. 106). The main character, Mary has just introduced Dickon to the secret garden and Dickon has discov-

[1] Equipment failure ($n = 4$) and an unwillingness to answer the questions ($n = 2$) resulted in the absence of the data for a total of six children over all three studies.

[2] Additional analyses, conducted for each of the three studies with a sample that included only the children who answered all of the story comprehension questions correctly, yielded no differences with respect to the significance of results of all analyses and thus the results reported here include the full sample of children for all three studies.

ered that, despite appearances, some of the plants in the garden may still be alive:

> "...this here's a new bit", and he touched a shoot that looked greenish-brown instead of hard, dry grey. Mary touched it herself in an eager, reverent way. "That one?" she said "is that one quite alive – quite?" Dickon curved his wide smiling mouth. "It's as wick as you or me," he said; and Mary remembered that Martha had told her that 'wick" meant "alive" or "lively." "I'm glad it's wick!" she cried out in her whisper. "I want them all to be wick. Let us go around the garden and count how many wick ones there are." She quite panted with eagerness, and Dickon was as eager as she was. They went from tree to tree and from bush to bush. Dickon carried his knife in his hands and showed her things she thought wonderful."

The above passage does not explicitly state how quickly Mary and Dickon moved about the garden, however, the use of the words "eager" and "eagerness" may easily lead an experienced reader to imagine Mary and Dickon moving fairly quickly from plant to plant inspecting each for signs of life. But how would a more inexperienced story listener, such as preschooler, comprehend a similar passage? Would young children's simulations of the character's movements reflect a character's eagerness?

To answer these questions, we created two new stories describing Jamie getting ready for an activity (e.g., going to the dentist or the ice cream store). We manipulated Jamie's eagerness by inserting a sentence in each story describing Jamie as thinking that an activity she was getting ready for was either "really great" (i.e., *eager* condition) or "really horrible" (i.e., *not eager* condition). Just as in the excerpt presented above, we hypothesized that a state of eagerness should result in a character moving more quickly (e.g., getting ready faster) than a state of non-eagerness, resulting in a character moving more slowly. Thus, the prediction with regard to processing times was that children's PTs should be faster when the character is progressing through the "getting ready" actions while thinking the activity he/she is getting ready for is "really great" as opposed to "really horrible."

3.1. Method

3.1.1. Participants

The participants were 48 native speakers of English with no reported history of speech or hearing difficulties: 24 4-year-olds (12 boys and 12 girls, mean age = 53 months, range = 47–59) and 24 5-year-olds (12 boys and 12 girls, mean age = 66 months, range = 61–71) drawn from a university child laboratory database. An additional seven children were tested but excluded from the dataset because of fussiness or unwillingness to listen to both of the stories.

3.1.2. Procedure and materials

Children were seated at a small table beside the experimenter. All children were administered the story listening task, followed by the CELF-P2 (Wiig et al., 2004) as described for Study 1. In addition, parents were asked to describe and rate their child's feelings about going to the ice cream store/dentist using a five point scale (i.e., 1 = child REALLY does not like going and 5 = child REALLY likes going to ice cream store/dentist). Children were asked to simply indicate, by replying yes or no, whether they liked going to either location. This information was important in demonstrating that, even if a child's perspective differed from the character's perspective, a child's simulation would reflect the character's perspective rather than their own.

3.1.2.1. Story listening task. The story listening task used in this study was essentially the same as the one used in Study 1. However, unlike Study 1, children in Study 2 listened to *two* different stories. Each story described the activities of a young child, Jamie, as she/he got ready to, and eventually engaged in, an activity (i.e., going to the ice cream store/dentist). Just as in Study 1, prior to the presentation of the stories, children were shown a laminated 11×8 in. drawing depicting Jamie, a friendly looking preschool boy for the boys and girl for the girls. The picture remained on the desk throughout the story listening task.

Each story consisted of four components (see Appendix B for an example story). Following the story introduction (Component 1), we manipulated the character's eagerness via the one sentence presented in Component 2. That is, in the *eager* condition, children heard that "Jamie thought that going to the ice cream store/dentist was really great". In the *not eager* condition, children heard that "Jamie thought that going to the ice cream store/dentist was really horrible." Immediately following this eagerness manipulation sentence, children heard the key focal six-sentence long description of Jamie's preparatory activities (i.e., changing clothes or cleaning up; Component 3). After the preparatory activities, children heard about Jamie's adventures at the ice cream store/dentist (Component 4). To assess children's ability to simulate the duration of a character's movement, we compared children's PTs collected during Jamie's preparatory activities (i.e., Component 3) in the eager condition of one story with the corresponding set of PTs in the not eager condition of the other story.

The activity (i.e., going to the ice cream store/dentist), the character's eagerness (i.e., eager/not eager), the two preparatory activities (i.e., changing clothes/cleaning up), and the presentation order of the stories (i.e., dentist story first/dentist second) were counterbalanced across children. Each child listened to one story about Jamie going to the ice cream store and one story about Jamie going to the dentist, each with a different eagerness manipulation and set of preparatory activities.

As in Study 1, to ensure that children were actively listening to the stories, the experimenter told the children that at the end of each story they would be asked some questions about the story and would receive a sticker for every correct answer. In an effort not to draw children's attention to the character's eagerness, children were not questioned about the character's thoughts about each activity. The three questions asked at the end of the ice cream story included: Where did Jamie go in that story?; What did Jamie eat when he/she got there? What kind of toppings did Jamie get on his/her ice cream? The three question asked at the end of the dentist story included: Where did Jamie go in that story?; Why did Jamie go to the dentist?; What happened to Jamie's tooth? Children were scored one point for every correct answer and could receive a total score of 6.

3.2. Results and discussion

Forty-four of 46 children answered at least five of the six questions correctly, suggesting that overall the children had complied with instructions and listened carefully to the story.[2] The data analysis focused on a comparison of the six PTs, for each child, during each of the character's preparatory activity sentences (Component 3) in both the eager condition and the not eager condition. Processing times that were four standard deviations from each participant's condition mean were considered outliers and eliminated from further analyses, resulting in the exclusion of 4% of the total data.

Participants' mean PTs were then submitted to a eagerness (eager vs. not eager) × age (4- vs. 5-year olds) × sex (male vs. female) × story order (eager/not eager vs. not eager/eager) × story version (eager to go to dentist/not eager to go to ice cream store vs. eager to go to ice cream store/not eager to go to dentist) repeated measures mixed model ANOVA with age, sex, story order, and story version as the between-subjects variables and eagerness as the within-subjects variable. The ANOVA did not reveal a main effect of age, $F(1, 32) = .7$, $MSE = 234{,}363$, $p = .41$, $\eta^2 = .02$; sex, $F(1, 32) = .001$, $MSE = 234{,}363$, $p = .98$, $\eta^2 = .00$; story order, $F(1, 32) = 2.1$, $MSE = 234{,}363$, $p = .16$, $\eta^2 = .06$; or story version, $F(1, 32) = 1$, $MSE = 234{,}363$, $p = .32$, $\eta^2 = .03$. None of these variables interacted with eagerness, all $ps > .15$.

The ANOVA revealed a main effect of eagerness, $F(1, 32) = 23.4$, $MSE = 69{,}318$, $p < .001$, $\eta^2 = .42$. Children's PTs were significantly faster when the character was described as thinking that the activity was "really great" (i.e., eager condition; $M = 676$ ms, SE = 49 ms), than when the character was described as thinking that the activity was "really horrible" (i.e., not eager condition; $M = 941$ ms, SE = 58 ms), resulting in a mean difference of 265 ms between conditions. Children's mean PTs were faster on all six sentences of Component 3 in the eager condition than in the not eager condition. Table 2 provides the results of more detailed sentence-by-sentence paired-samples *t*-test analyses of the eagerness effect.

Moreover, the main effect of eagerness was highly specific and confined only to the sentences pertaining to the character's preparatory activities (Component 3). That is, it was not observed for the eagerness manipulation sentence that immediately preceded the preparatory activities, even though the word 'horrible' or 'great' was explicitly stated (i.e., "Jamie thought that going to the ice cream store was really great/horrible"), $t(47) = 1.6$, $p = .15$, $M_{\text{Eager}} = 897$ ms, $M_{\text{Not Eager}} = 1030$ ms. It was also not observed for each of the two sentences immediately following the preparatory activity sentences (Sentence 12: $t(47) = 1.1$, $p = .27$ ($M_{\text{Eager}} = 758$ ms, $M_{\text{Not Eager}} = 889$ ms); Sentence 13, $t(47) = .05$, $p = .96$ ($M_{\text{Eager}} = 872$ ms, $M_{\text{Not Eager}} = 866$ ms). Nor was it observed for Component 1, $t(47) = .56$, $p = .58$ (M_{Eager} Condition = 1132 ms, $M_{\text{Not Eager}} = 1190$ ms) or Component 4, $t(47) = .18$, $p = .86$ ($M_{\text{Eager}} = 1055$ ms, $M_{\text{Not Eager}} = 1067$ ms).

Table 2
Children's PTs in Study 2, presented as a function of the six preparatory sentences[a] presented to children in the not eager and eager conditions ($N = 48$).

Preparatory sentences	Processing times (ms) Condition		Difference (SE)	*p*-Value
	Not eager	Eager		
1	1427	933	494 (108)	$p < .001$
2	832	557	275 (83)	$p = .002$
3	678	530	148 (76)	$p = .06$
4	852	640	212 (115)	$p = .07$
5	850	678	172 (86)	$p = .05$
6	1008	717	292 (111)	$p = .01$

[a] See Appendix B, example of Study 2 story, Components 3 (Sentences 6–11).

Correlation analyses revealed only a significant relation between children's performance on the story listening task (as assessed by processing time difference scores between the eager and not eager condition) and children's performance on the CELF-P2 Recalling Sentences in Context (RSC) supplementary subtest, $r(47) = .37$, $p < .015$ (all other p's > .25). The nature of the relation between children's RSC scores and their performance on the story listening task is not yet clear and warrants further study.

The results of the parent and child questionnaire do not suggest children's own feelings about the two activities (i.e., going to ice cream store/dentist) influenced their ability to simulate the character's actions. Overall, mothers rated their children's feelings about the dentist as positive (mean = 3.8 out of 5), and their feelings about the ice cream stores as very positive (mean = 4.8 out of 5). All of the children said that they liked going to the ice cream store. All but nine of the 48 children also said that they liked going to the dentist. Thus, on almost all not eager trials where the character was described as thinking the activity was "really horrible," the character's perspective differed from that of the child participant's perspective. Nevertheless, a significant effect of eagerness in the hypothesized direction was observed. Additionally, correlation analyses did not reveal a significant relation between children's performance on the story listening task (as assessed by processing time difference scores between the eager and not eager condition) and parent ratings' of their child's feelings about going to the dentist, $r(47) = .17$, $p = .27$, or the ice cream store, $r(47) = .16$, $p = .28$.

Overall, the results of this study suggest that children's expectations about the influence of certain motivating psychological factors (i.e., eagerness to get to a particular location) also influence children's simulations of the speed of a character's actions. Children's processing times were faster for sentences describing a child character "getting ready" (e.g., getting dressed) for an activity that he/she thinks is "really great" as opposed to "really horrible." Furthermore, children's own feelings about the activities the character was getting ready for did not influence children's processing times. That is children's processing time were consistent with the character's perspective, even when their own perspective toward each activity differed from that of the character's (e.g., child listener liked going to the ice cream store but story character thinks that going to the ice cream store is "really horrible").

4. Study 3

Study 3 was designed to continue our exploration of children's situation models by focusing on the manner in which children's expectations and spatial–temporal and psychological knowledge might combine together to influence their simulations of a character's movements. That is, to put our predictions and findings from Studies 1 and 2 to an even stronger test, we examined how the effect of the spatial–temporal movement variables (i.e., walking and driving) observed in Study 1 might be moderated by the psychological variable of eagerness investigated in Study 2. More specifically, among children randomly assigned to the walk condition ($N = 16$), the prediction was that a character's described state of eagerness (eager, not eager) would exert an influence on children's PTs, given that the speed of walking is under a person's control. Among children assigned to the drive condition ($N = 16$), however, the prediction was the opposite: namely, that a character's described state of eagerness (eager, not eager) would *not* exert an influence on children's PTs, given that the speed of being driven is not under a passenger's control.

4.1. Method

4.1.1. Participants

The participants were 32 4-year-old native speakers of English with no reported history of speech or hearing difficulties, drawn from a university child laboratory database: 16 boys and 16 girls (mean age = 55 months, range 48–61 months). Sixteen children (eight boys/girls) were randomly assigned to the walk condition (mean age = 55 months, range 48–61 months) and 16 to the drive condition (mean age = 55 months, range 48–61 months). An additional four children were tested but excluded from the dataset due to inattentiveness.

4.1.2. Procedure and materials

The walk condition explored the influence of the character's eagerness when the character walked to his/her aunt's house; while the drive condition explored the influence of eagerness when the character was driven to his/her aunt's house. The story listening task used in this study was identical to that of Study 1, with the exception of the inclusion of eagerness manipulation sentences used in Study 2 (i.e., "Jamie thought that going to aunt Alice's was really great/horrible."). This sentence was presented right after the movement manipulation sentence ("You know what Jamie? This time, let's walk/drive to aunt Alice's"). As shown in Appendix C, these eagerness manipulation sentences were inserted immediately following the 1st and 2nd movement manipulation sentences of Components 2 and 6. All other components of the story and procedure remained the same.

Each child heard the story once. As in Study 1, the presentation order of Components 3 and 7 (eagerness manipulation) and 4 and 8 (descriptions of scenery) were fully counterbalanced across children. As in Study 1, following the story, children were asked several story comprehension questions: two questions from Study 1 (Who did Jamie visit; What did Jamie do at aunt Alice's?) and two additional questions (Did Jamie want to go his/her aunt's house the first/s time?). Children received one point for every correct answer. Following the story listening task, children were administered the CELF-P2's (Wiig et al., 2004) core language subtests (Sentence Structure, Word Structure, and Expressive Vocabulary) as well as the Recalling Sentences in Context (RSC) supplementary subtest.

4.2. Results

Twenty-three of 30 children answered at least three of the four story questions correctly, suggesting that overall children had complied with instructions and listened carefully to the story. Two children would not respond to the story questions. The data analysis focused on a comparison of the four PTs collected, for each child, during the four-sentence description of scenery Jamie saw along the way to aunt Alice's house in the *eager* portion of the story with the four PTs collected for during the four-sentence description of scenery in the *not eager* portion of the story (i.e., story Components 4 and 8; eight PTs in total). Processing times that were four standard deviations from each participant's condition mean were considered outliers and eliminated from further analyses, resulting in the exclusion of 2.2% of the total data.

Participants' mean PTs were then submitted to an eagerness (eager vs. not eager) × speed of movement (walk vs. drive) × story order (eager/not eager vs. not eager/eager) × sex (male vs. female) repeated measures mixed model ANOVA with speed of movement, story order, and sex as the between-subjects factors and eagerness as the within-subjects factor. The ANOVA did not reveal a main effect of story order, $F(1, 24) = .4$, $MSE = 335{,}269$, $p = .53$, $\eta^2 = .02$; sex, $F(1, 24) = 2.3$, $MSE = 335{,}269$, $p = .14$, $\eta^2 = .09$; or speed of movement, $F(1, 24) = .72$, $MSE = 335{,}269$, $p = .4$, $\eta^2 = .03$. The ANOVA did reveal a main effect of eagerness, $F(1, 24) = 4.6$, $MSE = 156{,}494$, $p = .042$, $\eta^2 = .15$. Children's PT's were significantly faster in the eager condition ($M = 838$ ms, SE = 98 ms) than in the not eager condition ($M = 1049$ ms, SE = 76 ms). Critically, however, the analysis revealed a significant eagerness by speed of movement interaction, $F(1, 24) = 5.5$, $MSE = 156{,}494$, $p = .032$, $\eta^2 = .14$. As predicted, the effect of eagerness was only observed in the walk condition and not in the drive condition. The details of this interaction are explored below for the walk and drive condition separately.

As found in Studies 1 and 2, correlation analyses did not reveal a significant relation between children's performance on the story listening task (as assessed by processing time difference scores between the not eager and eager condition) and children's performance on any of the language subtests of the CELF-P2 in the walk condition

Table 3
Children's PTs in Study 3's walk condition, presented as a function of the four scenery sentences[a] presented to children in the not eager and eager conditions ($N = 16$).

Scenery sentences	Processing times (ms) Condition		Difference (SE)	*p*-Value
	Not eager	Eager		
1	1186	620	566 (221)	$p = .02$
2	1399	888	519 (270)	$p = .07$
3	875	484	390 (142)	$p = .02$
4	947	665	282 (191)	$p = .16$

[a] See Appendix C, example of Study 3 story, Components 4 and 8 (Sentences 8–11 and 28–31).

Table 4
Children's PTs in Study 3's drive condition, presented as a function of the four scenery sentences[a] presented to children in the not eager and eager conditions ($N = 16$).

Scenery sentences	Processing times (ms) Condition		Difference (SE)	*p*-Value
	Not eager	Eager		
1	858	736	122 (166)	$p = .47$
2	1354	1347	−7 (215)	$p = .94$
3	915	884	31 (274)	$p = .91$
4	859	1084	225 (308)	$p = .3$

[a] See Appendix C, example of Study 3 story, Components 4 and 8 (Sentences 8–11 and 28–31).

(all p's > .2) or in drive condition (all p's > .3). Children's core language scores also did not differ significantly across the two speed of movement conditions, $t(27) = 1.4$, $p = .27$.

4.2.1. Walk condition

Twelve out of 15 children answered at least three of the four story comprehension questions correctly, suggesting that overall children had complied with instructions and listened carefully to the story. The ANOVA did not reveal a main effect of story order, $F(1, 12) = 3.2$, $MSE = 198{,}419$, $p = .10$, $\eta^2 = .2$; or sex, $F(1, 12) = .1$, $MSE = 198{,}419$, $p = .75$, $\eta^2 = .009$. None of these variables interacted with eagerness, all $ps > .1$. Children's PT's were significantly faster in the eager condition ($M = 663$ ms, SE = 57 ms) than in the not eager condition ($M = 1102$ ms, SE = 146 ms), resulting in a main effect of eagerness, $F(1, 12) = 13.2$, $MSE = 112{,}999$, $p = .003$, $\eta^2 = .52$. Children's mean PTs were faster on all four scenery sentences (i.e., Components 4 and 8) in the eager condition than in the not eager condition. Table 3 provides the results of more detailed sentence-by-sentence paired-samples *t*-test analyses of the effect of eagerness.

Moreover, this effect of eagerness was highly specific and confined only to the sentences in Components 4 and 8 pertaining to the description of the scenery Jamie observed along the way to aunt Alice's house. That is, it was not observed for the eagerness manipulation sentence that immediately preceded the scenery description, even though the words 'great' or 'horrible' were explicitly stated (i.e., "Jamie thought that going to visit aunt Alice's was really *great/horrible*."; Components 3 and 7), $t(15) = .25$, $p = .8$ ($M_{\text{Not Eager}} = 1221$ ms, $M_{\text{Eager}} = 1326$ ms). It was also not observed on either of the two sentences immediately following each of the two key scenery description components (i.e., Sentence 12 or 32, $t(15) = 1.1$, $p = .27$, $M_{\text{Not Eager}} = 1550$ ms, $M_{\text{Eager}} = 1021$ ms; or Sentence 13 or 33, $t(15) = .98$, $p = .34$, $M_{\text{Not Eager}} = 1180$ ms, $M_{\text{Eager}} = 937$ ms. In addition, no significant eagerness effect was found for the remaining Components 5 and 9, $t(15) = 1.4$, $p = .19$, $M_{\text{Not Eager}} = 1463$ ms, $M_{\text{Eager}} = 1285$ ms.

4.2.2. Drive condition

Eleven of the 15 children answered at least three of the four story questions correctly, suggesting that overall children had complied with instructions and listened carefully to the story. As in the walk condition, the ANOVA did not reveal a main effect of story order, $F(1, 12) = 3.7$, $MSE = 472{,}118$, $p = .08$, $\eta^2 = .24$, or sex, $F(1, 12) = 4.1$, $MSE = 472{,}118$, $p = .07$, $\eta^2 = .26$; and none of these variables interacted with eagerness, all $ps > .4$.

Unlike the results of the walk condition, children's PTs were not significantly faster in the eager condition ($M = 1013$ ms, SE = 195 ms) than in the not eager condition ($M = 996$ ms, SE = 142 ms), $F(1, 12) = .015$, $MSE = 199{,}988$, $p = .90$, $\eta^2 = .001$.[3] Table 4 provides the results of more detailed sentence-by-sentence paired-samples *t*-test analyses of the eagerness effect. Children's mean PTs on the four scenery sentences (i.e., Components 4 and 8) revealed no consistent pattern of being faster or slower.

In addition, as in the previous studies, an effect of eagerness was not observed for the eagerness manipulation sentence that preceded the scenery description, $t(15) = .44$, $p = .67$ ($M_{\text{Not Eager}} = 1163$ ms, $M_{\text{Eager}} = 1298$ ms). It was also not observed on either of the two sentences immediately following each of the two key scenery description components (i.e., Sentence 12 or 32, $t(15) = .17$, $p = .87$, $M_{\text{Not Eager}} = 1076$ ms, $M_{\text{Eager}} = 1120$ ms; or Sentence 13 or 33, $t(15) = 1.5$, $p = .15$, $M_{\text{Not Eager}} = 850$ ms, $M_{\text{Eager}} = 1217$ ms. In addition, no significant eagerness effect was found for the remaining Components 5 and 9, $t(15) = .85$, $p = .41$, $M_{\text{Not Eager}} = 1117$ ms, $M_{\text{Eager}} = 1238$ ms.

4.3. Discussion

Overall the results of Study 3 suggest that children's simulations of a character's speed of movement are also constrained by the impact of a psychological factor, such as eagerness. Children PT's were faster when the character was described as eager, as opposed to not eager, to get to his/her aunt's house, but only when the speed of the character's movement was under his/her control; namely, when walking but not when being driven. Furthermore, in interpreting the results of Study 3, the reader is

[3] The reader may note that overall mean PTs are longer in the eager condition in Study 3's drive condition than Study 3's walk condition, and in turn question the coherence of these findings with respect to Study 1. The reader should recall that the data from Study 3's walk and drive condition are from two different groups of children. Just as in adult studies assessing reading times, our hypotheses are not about *absolute* values of processing times that would hold across different groups of children, but rather about *relative* differences observed for different conditions presented *within* subjects.

reminded that the scenery descriptions were counterbalanced across children, thus any differences with regard to their content and presentation order cannot account for the results. Overall, these findings support the hypothesis that children simulate a character's movement during story comprehension and that these simulations are constrained by their knowledge and expectations of the motivating influence of certain psychological states, specifically in this case, eagerness.

5. General discussion

The results of these three studies demonstrate that preliterate children construct rich mental representations of the events described in a narrative. Specifically, our results demonstrate that children simulate a character's movements and actions during story comprehension and that these simulations are constrained by children's expectations and knowledge of certain physical and psychological factors that can influence the duration of these movements.

Study 1 demonstrated that while listening to a story, children simulate a character's movements and that these simulations are influenced by children's *expectations about the duration of certain activities* such as walking and driving. Children's processing times were slower for scenery descriptions of what the character saw along the way to a relative's house when the character was described as walking as opposed to driving.

Study 2 demonstrated for the first time that preschoolers' simulations of character actions are constrained by the *motivating influence of certain psychological states such as eagerness*. When the character in the story was described as thinking an upcoming activity (e.g., going to ice cream store or dentist) was "really great," children's processing times were faster for sentences describing the character getting ready for this activity, than when the character was described as thinking the upcoming activity was "really horrible". Furthermore, the results of Study 2 indicate that preschoolers simulated a character's actions, even when their own perspective toward each activity differed from the character's (e.g., child listener liked going to the ice cream store but story character thinks that going to the ice cream store is "really horrible").

Study 3 extends the findings of Studies 1 and 2 by demonstrating that children's simulations of a character's speed of movement are also constrained by the impact of a psychological factor, such as eagerness. Children progressed through a description of the scenery and events a narrative character observed along the way to his/her aunt's house faster when the character was described as eager, as opposed to not eager, to get there, but only when the speed of the character's movement was under his/her control; namely, when walking but not when being driven.

Our studies make a novel methodological contribution to the study of narrative development in young children. Investigating children's story comprehension using a response-time based approach offers an alternative to methodologies requiring children to verbally produce narratives or answer comprehension questions. Our method is a sensitive measure of children's representation of characters and events, not easily demonstrated by children in more taxing verbal narrative tasks. A processing time methodology may also prove especially useful in the study of comprehension difficulties. Our method offers a unique and less taxing means of investigating these types of comprehension difficulties in young children.

Our results extend the findings of previous studies of children's situation models (Rall & Harris, 2000; Ziegler et al., 2005) in three main ways. Our study is the first to explore the systematic capacity of preschool-aged children to track the *spatial–temporal* aspect of a character's experience. Second, our studies extend previous findings by highlighting the dynamic nature of children's narrative comprehension. While previous studies have examined children's simulations of a character's perspective in a relatively static manner (i.e., the character was not actually moving), our study explored children's ability to simulate a character's spatial–temporal movement in space (i.e., the *speed* of movement). Third, Studies 2 and 3 explored children's simulations in the most depth yet, examining the interplay between children's expectations regarding physical constraints and psychological constraints on a character's speed of movement. Indeed, the results of these studies speak to arguments that narrative comprehension is an intricate skill that entails the integration of a large amount of information, including the ability to make inferences about information not explicitly stated in the text and the "understanding of abstract concepts such as characters' underlying motivations" (Lynch et al., 2008, p. 350).

The results of the present investigation also contribute to our understanding of how movement is represented in narratives by preschool-aged children. What makes the results of the present investigation especially interesting is that the key sentences (i.e., the movement manipulation sentences, the preparatory sentences and the scenery sentences) did not *explicitly* communicate the speed of the character's movement. Rather, children were just told that the character was walking or being driven or was eager or not eager. These findings further support the findings of other studies, albeit with adults, suggesting that mental simulation of motion is not limited to *explicit* descriptions of motion but rather generalizes to *implicit* types of descriptions of motion such as those expressed in fictive or figurative thought and language (Matlock, 2004).

With respect to the nature of children's simulations, we would also interpret our results as suggesting that these simulations involved more than just a representation and use of spatial information, similar to traditional spatial situation model effects (e.g., Bower & Morrow, 1990). That is, these results appear more in line with embodied accounts of comprehension that involve perceptual-motor simulation, as discussed in the introduction (e.g., Barsalou, 2008). We interpret the processing time effects observed in our studies as reflecting an automatic reactivation of experiential traces associated with the described events that, at minimum, encompassed information about the differing temporal duration (i.e., speed) of walking or being driven, or of moving more quickly or slowly (because one is eager or not eager). That is, children's processing times (which were not time restricted) for individual sentences in these studies are proposed to reflect children's automatic, simulation of the events described in a particular sentence, in addition, of course, to other linguistic and cognitive processes involved in the processing of spoken language (e.g., translating speech sounds into meaning).

Our results may also be viewed as a bit inconsistent with the results of the grounding training studies of Glenberg and colleagues (Glenberg, Brown, & Levin, 2007; Glenberg et al., 2009; Marley et al., 2007). Glenberg and colleagues argued that school-aged children needed to be taught how to ground words to their referents and that doing so aids comprehension. That is, in addition to decoding, Glenberg and colleagues argue that comprehension requires that readers map the abstract symbols of language "onto embodied experiences or representation of those experiences" (Glenberg et al., 2009, p. 3). Their findings have demonstrated that having children reproduce events and actions in a narrative via manipulatives that are physically interacted with or imagined increases comprehension performance. Our findings, however, demonstrate that children as young as 3 years of age generate simulations of narrative events spontaneously, without any instruction to do so. We believe that this discrepancy may be accounted for by a methodological difference between our studies and those of Glenberg and colleagues. Our studies focused on listening comprehension, whereas those of Glenberg and colleagues explored reading comprehension. The additional demands of reading comprehension (e.g., decoding) as compared to listening comprehension may make it difficult for some school-aged children to simulate the events described in a story.

Further studies will be needed to determine precisely, beyond duration, which perceptual and motor aspects of a character's described experience of moving faster or slower were simulated by children in our studies. For instance, when children listened to a sentence describing a character's movements (e.g., "On the way to aunt Alice's, they saw some dogs in a park"), how exactly was the simulation different in the drive condition as opposed to the walk condition? Were children "viewing" scenes in the drive condition in less detail than in the walk condition (e.g., a blurrier, more distant car seat window-framed view vs. clear, closer sidewalk view; Horton & Rapp, 2003)? Could this be revealed using a more visually based task that teases apart these alternatives? For example, as implemented in adult research, would children be faster to recognize a picture that was consistent with the described event than an inconsistent picture (e.g., Yaxley & Zwaan, 2007; Zwaan, Madden, Yaxley, & Aveyard, 2004)? Similarly, one could address in future studies whether there are further differences at the level of a child's motor system in response to hearing 'drive' vs. 'walk' or 'eager' vs. 'not eager', such as motor activity in the child's leg or activation of the leg area of the premotor cortex (i.e., motor resonance effects, Fischer & Zwaan, 2008). And indeed, whether an action is under a character's control or not may also have implications for children's simulations (e.g., attenuating effects). Further studies will also need to explore the intricate interplay between the different narrative dimensions (e.g., character's psychological states vs. motor actions) and how these may be more or less prominently featured in a simulation of narrative events.

Overall, our findings, we argue, underscore the importance of considering, and further investigating, the development and role of mental simulation in narrative comprehension. In particular, we would note that, although it has been argued that narrative comprehension is a critical component of, and precursor to, the acquisition of reading ability, recent reviews have highlighted the need for studies directed at children's comprehension, rather than production, of narratives, especially among typically developing children (e.g., Milosky & Skarakis-Doyle, 2007; Paris & Paris, 2003).

We believe the study of mental simulation in narrative may offer new insights into the development of narrative comprehension, especially given the complexity of these simulations in very young children. That such complexity exists, long before children are even able to read is exciting, as is the opportunity to learn more about this very fundamental aspect of how our minds process language and longer stretches of discourse and narrative. The processing time methodology we have developed may also prove useful in the further study of individual differences related to the ability to build adequate situation models and its possible relation to identifying children at risk for reading comprehension difficulties, even before they learn to read.

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Appendix A. Example of a story used in Study 1

A.1. Component 1: introduction

1. Jamie was at home playing in the playroom downstairs when her mom called to her and said,
2. "Jamie. It's almost time to go."
3. "As soon as you're finished playing, we're going to visit aunt Alice."
4. "Ok, mom" said Jamie.
5. Jamie tidied up her toys and went upstairs to put on her shoes.

A.2. Component 2: 1st movement manipulation

6. "You know what Jamie? This time, let's *walk* to aunt Alice's."

A.3. Component 3: description of scenery

7. On the way to aunt Alice's, they saw some dogs in a park;

8. And some kids playing baseball;
9. And squirrels running around someone's yard;
10. And even some kids sliding on a slide.

A.4. Component 4: visit

11. Aunt Alice lived all alone and sometimes needed help with the housework.
12. When they got to aunt Alice's, they helped her plant flowers in the backyard.
13. Jamie had a great time planting all the flowers.
14. When they were all done, aunt Alice brought out some lemonade and sandwiches and afterwards Jamie had a Popsicle.
15. But just when they were getting ready to go home, they heard a noise.
16. "It sounds like a meow!" said Jamie.
17. "Oh no! I think the neighbour's kitty is stuck in my tree" aunt Alice said.
18. "Let's get it down" all three of them said and Jamie's mom went to get a ladder.
19. Then, Jamie's mom climbed up the ladder and grabbed the scared kitty.
20. Then, they played with the kitty a bit but soon it was time to go home.
21. Then, Jamie and her mom went home.
22. But when they got home, Jamie's mom realized that she forgot something at aunt Alice's.
23. "Sorry, Jamie but we have to go out again. I forgot my cell phone at aunt Alice's" said Jamie's mom.
24. Jamie tidied up her toys and put on her shoes.

A.5. Component 5: 2nd movement manipulation

25. "You know what Jamie? This time, let's *drive* to aunt Alice's."

A.6. Component 6: description of scenery

26. On the way to aunt Alice's, they saw some ducks in the park;
27. And some kids playing soccer;
28. And birds flying around in someone's yard;
29. And even some kids swinging on a swing.

A.7. Component 7: conclusion

30. When they got to aunt Alice's, she was already waiting for them with the phone.
31. Then, Jamie and her mom went home to make dinner.

Appendix B. Example of a story used in Study 2

B.1. Component 1: story introduction

1. Jamie was at home playing when her mom called to her and said.
2. "Jamie, it's time to get ready."
3. "As soon as you're finished changing your clothes/cleaning up the mess you made in the backyard we're going to the ice cream store/dentist."
4. "Ok, mom" said Jamie.

B.2. Component 2: eagerness manipulation

5. Jamie thought that going to the ice cream store/dentist was really great/really horrible!

B.3. Component 3: preparatory activities

Changing clothes sequence of preparatory activities:

6. Jamie walked over to her dresser.
7. She put on her cool green t-shirt.
8. Jamie put on her socks.
9. She pulled on her favourite jeans.
10. And finally, Jamie put on her bright red sweatshirt.
11. Now Jamie was all ready to go.

or
Cleaning up mess in backyard sequence of preparatory activities:

6. Jamie went outside.
7. She picked up the blocks.
8. Jamie put the blocks in the bucket.
9. She picked up her ball.
10. And finally, Jamie walked back in.
11. Now Jamie was all ready to go.

B.4. Component 4: adventure

12. "Jamie, it's time to go" said Jamie's mom.
13. Jamie and her mom drove to the ice cream store/dentist's office.
14–31. Another 18 sentences describing Jamie's activities at the ice cream store/dentist.

Appendix C. Example of a story used in Study 3 – walk condition

C.1. Component 1: introduction

1. Jamie was at home playing in the playroom downstairs when her mom called to her and said,
2. "Jamie. It's almost time to go."
3. "As soon as you're finished playing, we're going to visit aunt Alice."
4. "Ok, mom" said Jamie.
5. Jamie tidied up her toys and went upstairs to put on her shoes.

C.2. Component 2: 1st movement manipulation

6. "You know what Jamie? This time, let's *walk* to aunt Alice's."

C.3. Component 3: 1st eagerness manipulation

7. "Jamie thought that going to visit aunt Alice's was really *great*."

C.4. Component 4: description of scenery

8. On the way to aunt Alice's, they saw some dogs in a park;
9. And some kids playing baseball;
10. And squirrels running around someone's yard;
11. And even some kids sliding on a slide.

C.5. Component 5: visit

12. Aunt Alice lived all alone and sometimes needed help with the housework.
13. When they got to aunt Alice's, they helped her plant flowers in the backyard.
14. Jamie had a great time planting all the flowers.
15. When they were all done, aunt Alice brought out some lemonade and sandwiches and afterwards Jamie had a Popsicle.
16. But just when they were getting ready to go home, they heard a noise.
17. "It sounds like a meow!" said Jamie.
18. "Oh no! I think the neighbour's kitty is stuck in my tree" aunt Alice said.
19. "Let's get it down" all three of them said and Jamie's mom went to get a ladder.
20. Then, Jamie's mom climbed up the ladder and grabbed the scared kitty.
21. Then, they played with the kitty a bit but soon it was time to go home.
22. Then, Jamie and her mom went home.
23. But when they got home, Jamie's mom realized that she forgot something at aunt Alice's.
24. "Sorry, Jamie but we have to go out again. I forgot my cell phone at aunt Alice's" said Jamie's mom.
25. Jamie tidied up her toys and put on her shoes.

C.6. Component 6: 2nd movement manipulation

26. "You know what Jamie? This time, let's *walk* to Aunt Alice's."

C.7. Component 7: 2nd eagerness manipulation

27. "Jamie thought that going to visit aunt Alice's was really *horrible*."

C.8. Component 8: description of scenery

28. On the way to aunt Alice's, they saw some ducks in the park;
29. And some kids playing soccer;
30. And birds flying around in someone's yard;
31. And even some kids swinging on a swing.

C.9. Component 9: conclusion

32. When they got to aunt Alice's, she was already waiting for them with the phone.
33. Then, Jamie and her mom went home to make dinner.

References

Anderson, A., Garrod, S. C., & Sanford, A. J. (1983). The accessibility of pronominal antecedents as a function of episode shifts in narrative text. *Quarterly Journal of Experimental Psychology, 35*, 427–440.

Audacity Developer Team, (2007). Audacity: The free, cross-platform sound editor. Audcitystore.com.

Barsalou, L. W. (1999). Perceptual symbol systems. *Behavioral and Brain Sciences, 22*, 577–660.

Barsalou, L. W. (2008). Grounded cognition. *Annual Review of Psychology, 59*, 617–645.

Black, J. B., Turner, T. J., & Bower, G. H. (1979). Point of view in narrative comprehension, memory, and production. *Journal of Verbal Learning and Verbal Behavior, 18*, 187–198.

Bower, J. G., & Morrow, D. G. (1990). Mental models in narrative comprehension. *Science, 247*, 44–48.

Brunyé, T. T., Ditman, T., Mahoney, C. R., Augustyn, J. S., & Taylor, H. A. (2009). When you and I share perspectives: Pronouns modulate perspective taking during narrative comprehension. *Psychological Science, 20*, 27–32.

Burnett, Hodgson (1909). *The secret garden*. Ware: Wordsworth Editions Ltd..

Fischer, M. H., & Zwaan, R. A. (2008). Embodied language – A review of the role of the motor system in language comprehension. *Quarterly Journal of Experimental Psychology, 61*, 825–850.

Gernsbacher, M. A., Goldsmith, H. H., & Robertson, R. R. W. (1992). Do readers mentally represent characters' emotional states? *Cognition and Emotion, 6*, 89–111.

Gerrig, R. J. (1993). *Experiencing narrative worlds: On the psychological activities of reading*. New Haven, CT: Yale University Press.

Glenberg, A. M. (2007). Language and action: creating sensible combinations of ideas. In G. Gaskell (Ed.), *The Oxford handbook of psycholinguistics* (pp. 361–370). Oxford, UK: Oxford University Press.

Glenberg, A. M., Brown, M., & Levin, J. R. (2007). Enhancing comprehension in small reading groups using a manipulation strategy. *Contemporary Educational Psychology, 32*, 389–399.

Glenberg, A. M., Goldberg, A. B., & Zhu, X. (2009). Improving early reading comprehension using embodied CAI. *Instructional Science*. doi:10.1007/s11251-009-9096-7.

Glenberg, A. M., & Kaschak, M. P. (2002). Grounding language in action. *Psychonomic Bulletin and Review, 9*, 558–565.

Graesser, A. C., Singer, M., & Trabasso, T. (1994). Constructing inferences during narrative text comprehension. *Psychological Review, 101*, 371–395.

Havas, D. A., Glenberg, A. M., & Rinck, M. (2007). Emotion simulation during language comprehension. *Psychological Bulletin & Review, 14*, 436–441.

Horton, W., & Rapp, D. N. (2003). Out of sight, out of mind: Occlusion and the accessibility of information in narrative comprehension. *Psychonomic Bulletin and Review, 10*, 104–109.

Johnson-Laird, P. N. (1983). *Mental models: Towards a cognitive science of language, inferences, and consciousness*. Cambridge, MA: Harvard University Press.

Kintsch, W. (1998). *Comprehension: A paradigm for cognition*. New York: Cambridge University Press.

Louwerse, M. M., & Jeuniaux, P. (2008). Language comprehension is both embodied and symbolic. In M. de Vega, A. Glenberg, & A. C. Graesser (Eds.), *Symbols and embodiment: Debates on meaning and cognition* (pp. 309–326). Oxford: Oxford University Press.

Lynch, J. S., Van Den Broek, P., Kremer, K. E., Kendeou, P., White, M. J., & Lorch, E. P. (2008). The development of narrative comprehension and its relation to other early reading skills. *Reading Psychology, 29*, 327–365.

Marley, S. C., Levin, J. R., & Glenberg, A. M. (2007). Improving native American children's listening comprehension through concrete representations. *Contemporary Educational Psychology, 32*, 537–550.

Matlock, T. (2004). Fictive motion as cognitive simulation. *Memory and Cognition, 32*, 1389–1400.

Milosky, L. A., & Skarakis-Doyle, E. (2007). What else about comprehension? Examining young children's discourse comprehension abilities. In R. Paul (Ed.), *Language disorders from a developmental perspective: Essays in honor of Robin S. Chapman* (pp. 377–403). Mahwah, NJ, US: Lawrence Erlbaum Associates Publishers.

Morrow, D. G., Bower, G. H., & Greenspan, S. L. (1989). Updating situation models during narrative comprehension. *Journal of Memory and Language, 28*, 292–312.

Morrow, D. G., Greenspan, S. L., & Bower, G. H. (1987). Accessibility and situation models in narrative comprehension. *Journal of Memory and Language, 26*, 165–187.

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*, 1032–1037.

Özyürek, A., & Trabasso, T. (1997). Evaluation during the understanding of narratives. *Discourse Processes, 23*, 305–337.

Paris, A. H., & Paris, S. G. (2003). Assessing narrative comprehension in young children. *Reading Research Quarterly, 38*, 36–76.

Pecher, D., & Zwaan, R. A. (2005). *Grounding cognition: The role of perception and action in memory, language, and thinking*. Cambridge, UK: Cambridge University Press.

Perfetti, C. A., Landi, N., & Oakhill, J. (2005). The acquisition of reading comprehension skill. In M. J. Snowling & C. Hulme (Eds.), *The science of reading: A handbook* (pp. 227–247). Oxford: Blackwell Publishing.

Perner, J. (1991). *Understanding the representational mind*. Cambridge, MA: MIT Press.

Pulvermüller, F. (2005). Brain mechanism linking language and action. *Nature, 6*, 576–582.

Rall, J., & Harris, P. L. (2000). In Cinderella's slippers? Story comprehension from the protagonist's point of view. *Developmental Psychology, 36*, 202–208.

Rapp, D. N., Klug, J. L., & Taylor, H. A. (2006). Character movement and the representation of space during narrative comprehension. *Memory and Cognition, 34*, 1206–1220.

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*, 988–1001.

Schneider, W., Eschmann, A., & Zuccolotto, A. (2002). *E-prime*. Pittsburgh, PA.

Semin, G. R., & Smith, E. R. (2008). *Embodied grounding: Social, cognitive, affective, and neuroscientific approaches*. New York, NY: Cambridge University Press.

Skarakis-Doyle, E., & Dempsey, L. (2008). Assessing story comprehension in preschool children. *Topics in Language Disorders, 28*, 131–148.

Speer, N. K., Reynolds, J. R., Swallow, K. M., & Zacks, J. M. (2009). Reading stories activates neural representations of visual and motor experiences. *Psychological Science, 20*, 989–999.

Stanfield, R. A., & Zwaan, R. A. (2001). The effect of implied orientation derived from verbal context on picture recognition. *Psychological Science, 12*, 153–156.

Tapiero, I. (2007). *Situation models and levels of coherence: Toward a definition of comprehension*. Mahwah, NJ, US: Lawrence Erlbaum Associates Publishers.

Trabasso, T., & Suh, S. Y. (1993). Understanding text: Achieving explanatory coherence through ongoing inferences and mental operations in working memory. *Discourse Process, 16*, 3–34.

Tversky, B. (2004). Narratives of space, time, and life. *Mind and Language, 19*, 380–392.

Wellman, H. M. (2004). Understanding the psychological world: Developing a theory of mind. In U. Goswami (Ed.), *Blackwell handbook of childhood cognitive development* (pp. 167–187). Malden, MA, US: Blackwell Publishing Ltd.

Wiig, E. H., Secord, W. A., & Semel, E. (2004). *Clinical evaluation of language fundamentals preschool – second edition and edition examiner's manual*. San Antonio, TX: PsychCorp Harcourt Assessment, Inc.

Wilson, G. M. (2003). Narrative. In J. Levinson (Ed.), *Oxford handbook of aesthetics* (pp. 392–407). Oxford: Oxford University Press.

Wolf, M. (2007). *Proust and the squid: The story and science of the reading brain*. New York: Harper Collins.

Yaxley, R. H., & Zwaan, R. A. (2007). Simulating visibility during language comprehension. *Cognition, 105*, 229–236.

Ziegler, F., Mitchell, P., & Currie, G. (2005). How does narrative cue children's perspective taking? *Developmental Psychology, 41*, 115–123.

Zwaan, R. A. (1994). Effects of genre expectations on text comprehension. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 20*, 920–933.

Zwaan, R. A. (1999). Situation models: The mental leap into imagined worlds. *Current Directions in Psychological Science, 8*, 15–18.

Zwaan, R. A. (2004). The immersed experience: Toward an embodied theory of language comprehension. In B. H. Ross (Ed.). *The psychology of learning and motivation* (Vol. 44, pp. 35–62). New York: Academic Press.

Zwaan, R. A., & Madden, C. J. (2005). Embodied sentence comprehension. In D. Pecher & R. A. Zwaan (Eds.), *Grounding cognition: The role of perception and action in memory, language, and thinking* (pp. 224–245). New York: Cambridge University Press.

Zwaan, R. A., Madden, C. J., Yaxley, R. H., & Aveyard, M. E. (2004). Moving words: Dynamic mental representations in language comprehension. *Cognitive Science, 28*, 611–619.

Zwaan, R. A., & Radvansky, G. A. (1998). Situation models in language comprehension and memory. *Psychological Bulletin, 123*, 162–185.

Zwaan, R. A., & Singer, M. (2003). Text comprehension. In A. C. Graesser, M. A. Gernsbacher, & S. R. Goldman (Eds.), *Handbook of discourse processes* (pp. 83–121). Mahwah, NJ: Lawrence Erlbaum Associates, Inc..

Zwaan, R. A., Stanfield, R. A., & Yaxley, R. H. (2002). Language comprehenders mentally represent the shapes of objects. *Psychological Science, 13*, 168–171.