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Effects of Social-Cognitive Processing Demands and Structural Importance on Narrative Recall: Differences Between Children, Adolescents, and Adults

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This study examined the contributions of developmental changes in social-cognitive ability throughout adolescence to the development of narrative comprehension. We measured the effects of sensitivity to the causal structure of narratives and of sensitivity to differences in social-cognitive processing demands on narrative recall by children (8–10 years old), adolescents (13–15 years old), and adults (19–21 years old). Generalized mixed-effects models for dichotomous variables revealed that social-cognitive processing demands of story elements predicted differences in narrative recall between the age groups, over and above the causal importance of story elements. Children's and adolescents' recall of the narrative differed from that of adults, and these differences were most apparent for social-cognitive aspects of the narrative. These findings suggest that immature social-cognitive abilities limit narrative comprehension in childhood and adolescence and, in doing so, contribute to our understanding of the interaction between reader characteristics and text characteristics in the development of narrative comprehension.

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INTRODUCTION

Learning to read and understand texts is one of the key higher-order cognitive functions for children to acquire. Not only does this ability give children access to the most prominent form of transmission of information in education, it also opens a world of stories for them to enjoy. In addition, research has stressed that reading fiction could make important contributions to the development of social-cognitive abilities such as empathy, perspective taking, and theory of mind (Kidd & Castano, 2013; Mar & Oatley, 2008). Even though the importance of reading is clear and reading skills are practiced throughout elementary school, text comprehension difficulties are quite common in childhood and adolescence. For example, the latest results from the Program for International Student Assessment of the Organization for Economic Co-operation and Development (2014) show that among Dutch 15-year-old adolescents, 14% of students have substandard reading abilities. In the United States and United Kingdom this percentage is even higher (17%). To understand and possibly remediate these comprehension difficulties, insight in the factors that contribute to narrative comprehension in children and adolescents is important because most reading skills are acquired and practiced in the context of narrative texts.

Narrative texts contain a considerable amount of information about mental states and often explicitly mention a character's feelings, thoughts, and intentions (Dyer, Shatz, & Wellman, 2000). Even though theories on reading comprehension stress that goal-directed or goal-oriented inferences that are likely to require perspective-taking are particularly important for narrative comprehension (e.g., Graesser, Singer, & Trabasso, 1994; Singer, Graesser, & Trabasso, 1994; Trabasso, van den Broek, & Suh, 1989), relatively little is known about the relation between the development of social-cognitive abilities and the development of narrative comprehension in childhood and adolescence. We argue that a more thorough understanding of this relation is important, because immature social-cognitive abilities may limit comprehension.

To accurately comprehend a narrative, it is often necessary that the reader infers the emotional state of the story characters and takes into account the perspective of the protagonist and other story characters. When a reader does not adopt the correct perspective during reading, he or she may fail to attend to crucial relations between different text elements as well as between text elements and background knowledge and may not include this information in his or her mental representation of the text. This may be the case, for example, if the goal of the protagonist is perpendicular to the intentions of another story character but at the same time successful completion of the protagonist's goal is contingent on interaction with this other character (Stein & Trabasso, 1982). Results from the Progress in International Reading Literacy Study (PIRLS; Mullis, Martin, Foy, & Drucker, 2012) assessment show that 10% of Dutch children and 12% of children

from the United States in fourth grade fail to make inferences regarding the main character's traits, beliefs, feelings, and motivations. Given recent insights in the development of social-cognitive abilities this is not surprising. Numerous studies have shown that these abilities (e.g., empathy, theory of mind, perspective-taking, and the ability to infer others' intentions, beliefs and desires, that could be important for understanding narrative texts; Davis, 1980) continue to develop well into adolescence (see e.g., Blakemore, 2008; Burnett, Sebastian, Cohen Kadosh, & Blakemore, 2011).

The aim of this study was to gain insight into the relation between social-cognitive development and reading-comprehension development. We examined the ability to create a coherent mental representation of a text as well as the content of that representation in children, adolescents, and young adults by analyzing their recall of a narrative that contained both social and nonsocial information.

Structural Centrality

Whereas little attention has been paid to the relation between social-cognitive abilities and reading-comprehension development, a considerable amount of literature has been published on the cognitive processes involved in reading comprehension and the development of reading-comprehension skills. During reading, readers create a coherent mental representation, or a situation model, of the text (Kintsch, 1998; Zwaan & Radvansky, 1998). To construct such a representation a reader must interpret each text element separately and identify meaningful associations with other elements in the text. This usually requires readers to infer semantic connections between text components and between text components and their background knowledge (Kendeou, van den Broek, White, & Lynch, 2009). These semantic connections between text elements form the basis for a coherent situation model.

An important type of connection is the causal connection. Causal connections in a narrative can be captured in a causal network model of the text (Trabasso et al., 1989). The importance, or centrality, of text elements to the causal structure of the text is reflected in the number of causal connections that text elements have in this causal network. Readers recall text elements with a large number of causal connections more often than text elements with few connections. This effect of the number of causal connections on the recall of text elements has been found in 4-year-old children, 6-year-old children, and adults (Brown & Smiley, 1977; van den Broek, Lorch, & Thurlow, 1996). However, the strength of the effect of the number of causal connections on recall increases with age (van den Broek, Risden, Fletcher, & Thurlow, 1996). Additionally, when asked to judge a story element's relative importance 8- and 10-year-old children have difficulty distinguishing relatively important story elements from relatively less-important

story elements (Brown & Smiley, 1977). This suggests that adults are more sensitive to differences in the importance of story elements and thus to the causal structure of the text than young children; in other words, adults show more *sensitivity to structural centrality* compared with children (van den Broek, Lorch, et al., 1996; Lynch et al., 2008; see also Brown & Smiley, 1977). These findings imply that whereas children identify and process information that is central to the causal structure of the text, they do so to a lesser extent than adults do. The degree to which readers are sensitive to the causal structure of a text is an important indicator of comprehension skills and this sensitivity increases with age (van den Broek, Helder, & Van Leijenhorst, 2013). The feelings, goals, and motivations of the protagonist usually are an essential part of the causal structure of the text (e.g., Dijkstra, Zwaan, Graesser, & Magliano, 1994; Stein & Levine, 1989). Moreover, models of reading comprehension have distinguished between different types of causal connections, for example, enabling psychological, motivational, and physical causal relations (Trabasso et al., 1989). These types of causal connections vary in the degree to which they require social-cognitive processing skills.

Social Cognition and Reading Comprehension

Developmental studies have shown that in children as young as 6 years old, theory-of-mind ability predicts listening comprehension and that listening comprehension, in turn, influences reading-comprehension proficiency (Kim, 2015). This finding is consistent with other findings that inferences involving story character goals contribute to narrative comprehension by 6-year-old children (Lynch & van den Broek, 2007): Recall of a story could be predicted from the number of goal inferences the children made. Although the children were able to take the character's perspective into account, the findings also indicate they did so less effectively than adults. Likewise, children are more likely to include characters' actions in their mental representation of a text, whereas adults are more likely to include characters' goals into their mental representation of a text (van den Broek, Lorch, et al., 1996). A crucial factor in such differences between children and adults likely is that the social-cognitive abilities that are needed to make these inferences are immature in children. A recent study showed that 5-, 8-, and 10-year-old children are able to infer the emotional state of story characters, albeit from short movies and audiobooks, but that their inferences become more precise with development (Diergarten & Nieding, 2015). These findings suggest that inferring emotional states is important for narrative comprehension and point to the important role of the interaction between reader characteristics and text characteristics. For example, a computational simulation of narrative understanding that includes emotional inferences predicted adults' memory for narratives better than a simulation without emotional inferences (Marotto, Barreyro, Cevasco, & van den Broek, 2011). Adult readers consistently

infer the emotional state of story characters during reading, and this seems to happen with little effort. For example, participants are faster to read emotion words that match the emotion that could be ascribed to a story character even under dual cognitive load conditions (Gernsbacher, Hallada, & Robertson, 1998). Further support for the idea that reading comprehension skills benefit from increasing social-cognitive abilities comes from work in the field of developmental disorders. Using observational and experimental methods, Ricketts, Jones, Happé, and Charman (2013) found that reading comprehension by 14- to 16-year-old children with an autism-spectrum disorder was predicted by social-cognitive ability over and above the influence of word recognition and listening comprehension.

Protracted Development of Social-Cognitive Abilities

Many behavioral studies have shown that social-cognitive abilities such as perspective taking (e.g., Dumontheil, Apperly, & Blakemore, 2010; Martin, Sokol, & Elfers, 2008) and the ability to understand and act upon the feelings, thoughts, and intentions of others continue to develop throughout adolescence (see also Gurucharri & Selman, 1982; Van der Graaff et al., 2014). With development, perspective-taking ability improves (Choudhury, Blakemore, & Charman, 2006; Martin et al., 2008). For example, McHugh, Barnes-Holmes, and Barnes-Holmes (2004) report that 6- to 8-year-old and 9- to 11-year-old children make significantly more mistakes during a perspective-taking task than 18- to 30-year-old adults, which suggests that performance continues to develop in adolescence. Similarly, Choudhury et al. (2006) asked participants to indicate which of two emotional faces corresponded to how either the participant would feel or how a protagonist would feel in a certain situation. They found that both preadolescent children (mean age 8.6 years) and adolescents (mean age 12.8 years) have more difficulty answering these questions compared with young adults (mean age 24 years). Additionally, Dumontheil et al. (2010) found that 14- to 18-year-old adolescents are less able to carry out instructions when this requires them to take the perspective of another person into account than 19- to 27-year-old adults.

The behavioral changes in the social-cognitive domain during adolescence have been related to developmental changes in the brain (e.g., Blakemore, 2008; Crone & Dahl, 2012; Nelson, Leibenluft, McClure, & Pine, 2005). Developmental-cognitive neuroscience work has shown that many of the brain regions implicated in social-cognitive processes show large functional and structural changes throughout adolescence (Blakemore, 2008; Mills, Lalonde, Clasen, Giedd, & Blakemore, 2014). Interestingly, cognitive neuroscience studies in adults have revealed considerable overlap in the network of brain regions that enables social cognition and the network of brain regions that

underlies narrative comprehension (e.g., Ferstl, Rinck, & von Cramon, 2005; Ferstl, 2015; for a meta-analysis see Mar, 2011). Immaturity of the brain regions that underlie social-cognitive processing in children and adolescents is likely to limit their ability to process social-cognitive information in narratives as well. Interestingly, a recent study examined the ability to make socioemotional inferences in narratives in a group of patients with lesions in one of the brain regions that underlie social-cognitive processing and found that in this patient group the ability to make socioemotional inferences was indeed impaired (Burin et al., 2014).

Current Study

In summary, story elements in narrative texts differ in the degree to which they require social-cognitive processing; some comprise social-cognitive aspects, whereas others do not. Because perspective taking, an important aspect of social-cognitive development, continues to develop well into adolescence (e.g., Blakemore, 2008), age-related differences in the recall of story elements that contain social-cognitive aspects are plausible. Story elements in a text are not equally important for creating a coherent mental representation of the text; for example, the number of causal connections that story elements have in a causal network of the text differs and is an important factor in comprehension. The sensitivity to this causal structure of a text increases with age (Lynch et al., 2008). Given the literature reviewed above, there are many reasons to expect a relation between reading-comprehension development and social-cognitive development.

In the current study, we examined the possible effect of story-element characteristics, reader characteristics, and the interaction between these factors on story-element recall. The aim of the experiment was twofold; the first aim of this study was to investigate age-related differences in narrative recall by examining the effects of differences in social-cognitive processing demands of story elements. To explore whether social-cognitive development contributes to reading comprehension over and above the previously reported age-related increase in sensitivity to structural centrality, the second aim of this study was to investigate age-related changes in narrative recall by examining the effects of differences in the structural importance of story elements.

In this study children (8–10 years), adolescents (13–15 years), and adults (19–21 years) read and recalled a narrative in which story elements differed both in their importance in the causal structure of the text and in the extent to which they contained social-cognitive information. We examined differences in participants' memory of the text and interpret these as reflecting differences in the mental representation of the text that they created during reading. Our first hypothesis was that immature social-cognitive abilities in childhood and adolescence limit processing of story elements that contain social-cognitive information and,

as a consequence, have a negative effect on subsequent recall of these social story elements by children and adolescents. We do not expect to find such differences in adults. Our second hypothesis was that recall of narratives increases with age but that this increase is larger for social story elements than for nonsocial story elements. Our third hypothesis was that sensitivity to the causal structure of the text increases with age. As a consequence, the effect of story-element importance is expected to be larger in adults than in children and adolescents.

METHODS

Participants

In total, 100 individuals participated in this study. Thirty-three children (17 girls) aged between 8 and 10 ($M = 9.81$; $SD = .57$) and 30 adolescents (12 girls) aged between 13 and 15 ($M = 14.73$; $SD = .51$) were recruited from various primary schools and general and preuniversity secondary schools in The Netherlands. Thirty-seven young adults (19 women) aged between 19 and 21 were recruited from a university population ($M = 19.95$; $SD = .57$, most were students in the social and behavioral sciences). After informed consent was obtained from either the parents (for the children and adolescents) or the participant (for the adults), participants were screened for exclusion criteria. Data from individuals for whom Dutch was not their mother tongue ($n = 2$) as well as data from individuals with diagnosed neurological or learning disabilities ($n = 1$) were excluded. Additionally, data from five participants were excluded due to technical difficulties such as loss of audio files. Consequently the final sample consisted of 29 children between ages 8 and 10 years ($M = 9.77$; $SD = .57$; 15 girls; U.S. grades 4–5), 29 adolescents between ages 13 and 15 years ($M = 14.75$; $SD = .51$; 12 girls; U.S. grades 9–10), and 34 young adults between ages 19 and 21 years ($M = 19.94$; $SD = .57$; 18 women). Because the onset of puberty is associated with changes during social-cognitive development and because pubertal maturation typically begins 1 or 2 years earlier in girls than in boys (Crone & Dahl, 2012), we ensured that the number of females and males in each age group was roughly balanced.

Measurement Instruments

Reading materials. Participants read two short texts: a child-friendly narrative text about a mole who wanted to buy a shovel (based on stories used by Goldman & Varnhagen, 1986 and by van den Broek, 1988) and an expository text about the characteristics of a mole. This study focuses on the narrative text (see Figure 1 for the complete story).

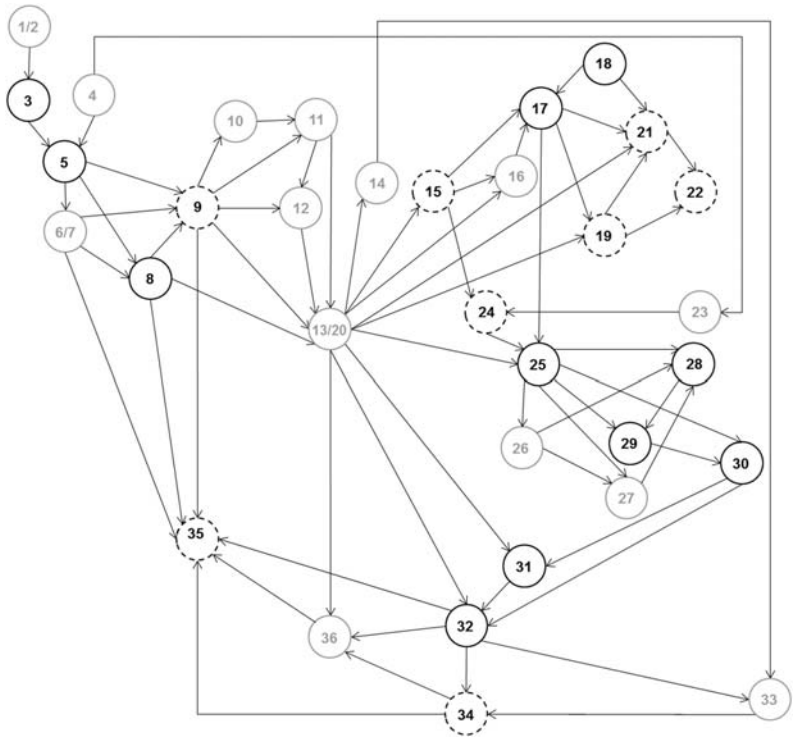

FIGURE 1 Causal network for *Lommie and his shovel*. Black circles represent nonsocial story elements, black dashed circles represent social story elements, gray circles represent filler story elements: 1/2 = Once upon a time there was a mole, 3 = called Lommie. 4 = One day, 5 = Lommie saw 6/7 = his friend Tom 8 = with a new shovel. 9 = Together they played with the shovel. 10 = Lommie pretended it was a guitar. 11 = Lommie made beautiful music with the shovel, 12 = Tom laughed and danced. 13 = Lommie wanted a new shovel as well, 14 = preferably a beautiful red one. 15 = Lommie went to talk to his mother, 16 = to ask her if she could buy him one. 17 = Lommie's mother could not afford a shovel, 18 = because they were very poor. 19 = Lommie was very sad, 20 = he wanted the shovel very badly. 21 = He told his mother that he didn't mind 22 = and concealed his tears. 23 = The next day, 24 = Lommie told his mother, 25 = that he wanted to save money for a shovel. 26 = He asked in the nearby supermarket 27 = if they had a job for him. 28 = He worked in the supermarket 29 = and made a lot of money. 30 = When Lommie had earned enough money 31 = he went to the store. 32 = He bought a new shovel 33 = in the most beautiful color they had. 34 = What a beautiful shovel! Lommie thought 35 = and he quickly went to his friend Tom 36 = to show it to him.

The technical reading level of the narrative text was suitable for children from Grade 3 and up, as evaluated by a measure that assesses average word length and the proportion of high frequency words (*Cito Index voor LeesTechniek*; Staphorsius & Verhelst, 1997; Evers, 1994–2008). The text contains 202 words

(not including title), of which 87% are high frequency words (Staphosius, Krom, & De Geus, 1988). The text is likely to be understood by children with a reading comprehension level that is comparable with the average reading comprehension level of children at the end of Grade 4, as indicated by the Dutch readability index (*Cito LeesIndex voor het Basis-en speciaal onderwijs*; Staphorsius, 1994; Evers 1994–2008). The Dutch national institute for measurement in education (*Centraal Instituut voor Toetsontwikkeling*) developed both measures.

Offline recall. Recall of the narrative text was used to measure reading comprehension. For this purpose, the text was parsed into clauses containing a predicate (cf. Trabasso et al., 1989; see also Stein & Glenn, 1979), defined informationally as major propositions (cf. Kintsch & Van Dijk, 1978). The resulting story elements were coded as a function of social-cognitive processing demands. To ensure that this distinction represented story elements that truly required social-cognitive processing versus story elements that clearly did not require social-cognitive processing, a tripartite distinction was made: social (elements that encompassed social interaction, perspective-taking, or emotion of the protagonist), nonsocial, and other. A story element was coded as social when the element met one or more of the following five requirements: (1) emotions of the story character were expressed in the story element, (2) the story character took the perspective of one of the other story characters into account in that story element, (3) a story character recognized the emotions of another character in the story element, (4) the story character showed an empathic response to another character in the story element, and (5) social interaction took place in the story element. These requirements are based on the definition of the concept of empathy (Davis, 1980; Marshall, Hudson, Jones, & Fernandez, 1995). For example, the story element in which the mole conceals his tears from his mother not to hurt her was coded as a social story element. When a story element clearly did not meet any of these requirements the element was coded as nonsocial (e.g., "he worked in the supermarket" was coded as a nonsocial story element). The remainder of the story elements was not included in the analyses (from hereafter referred to as "fillers") because they were either ambiguous with regard to their social-cognitive processing demands or belonged to content categories not relevant to the hypotheses, such as temporal markers and the settings. For example, "the mole asked in the nearby supermarket if they had a job for him" was coded as filler. This story element is difficult to classify as either social or nonsocial because one could argue that there is interaction in this situation as implied by the word "ask," but one could also argue that there is no social interaction as the supermarket is referred to as an object. Parsing and coding of the story materials was performed collaboratively in our lab and differences in opinion were resolved by discussion. To check for consistency, the collaborative coding of the social-cognitive processing demands of the materials was validated

by an independent research assistant who was naïve to the hypotheses of the study. The inter-rater reliability statistic indicated strong agreement, Cohen's kappa = .77, 95% CI [.59, .96].

In addition, story elements were coded as a function of structural importance based on their causal connectedness, that is, their number of connections in the causal network of the text, based on principles of causality (Trabasso et al., 1989): less important (≤3 connections) or important (≥4 connections). See Table 1 for the frequencies of each type of story element in the text.

Participants' responses were recorded, transcribed, and parsed into clauses containing a predicate (cf. Trabasso et al., 1989; see also Stein & Glenn, 1979), defined informationally as major propositions (cf. Kintsch & Van Dijk, 1978). Recall was scored dichotomously for each story element: mentioned by the participant or not mentioned by the participant. Synonyms, elaborations, and omissions were allowed as long as the gist of the story element was maintained (cf. Linderholm et al., 2000; Wolfe & Mienko, 2007). Twenty-five percent of the recalls, selected at random, were coded by a research assistant blind to the hypotheses of the study. The inter-rater reliability statistic indicated very high agreement, Cohen's kappa = .82, 95% CI [.77, .86].

Procedure

Data were collected from individual participants in a quiet room (at school or at the university). First, participants read one of the texts from paper: The child-friendly narrative text about a mole and his friend or an expository text about moles. The order of these texts was alternated between participants. Participants

TABLE 1
Story-Element Characteristics of the Narrative

	Importance			
Social-cognitive processing demands	*Less important (≤3 connections)*	*Important (≥4 connections)*	*Total*	*Example*
Nonsocial	4	7	11	"He worked in the supermarket"
Social	2	6	8	"He concealed his tears (from his mother)"
Other (filler)	9	4	13	"The mole asked at a nearby supermarket whether they had a job for him"
Total	15	17	32	

Values refer to frequency.

were instructed to read as they normally would (not slower or faster) and to indicate when they had finished reading the text, allowing us to measure reading duration. After reading each text participants were asked to recall the text as if they were telling the text to someone who had not read it. They were asked to try to recall the text in the correct order but were told that they could do this in their own words. When participants ended their recall, the experimenter told them they did very well and asked whether they could remember anything else. This was always repeated twice before moving on to the next text. They then repeated this procedure with the second text. Participants took approximately 1 minute to read the narrative. An ANOVA with reading time as dependent variable showed a significant effect of age group, $F(2, 87) = 5.41$, $p = .006$, indicating that children ($M = 76$ s) took significantly longer to read the narrative than did adolescents ($M = 63$ s) who, in turn, took significantly longer than did the young adults ($M = 59$ s), both p's $< .05$. The entire experiment took approximately 20 minutes to complete. At the end of the session participants were thanked for their participation and received a small gift.

Data Analysis

To examine possible effects of story-element characteristics (social-cognitive processing demands and structural importance), person characteristics (age group, gender), and possible interactions on story-element recall, generalized linear mixed-effect models (GLMMs) were fitted to the recall data. Because the outcome variable—recall (yes or no) of each story element—was dichotomous, a logistic link-function was specified. GLMM analysis allows for the inclusion of random effects. This was necessary because of the multilevel structure of the data, with story elements nested within individuals. Because of this nesting, participants' responses to the different story-element types were dependent, and these intraparticipant dependencies were accommodated with a random intercept over persons. Furthermore, a random intercept over story elements was added to account for general differences in difficulty between the various story elements. For example, word meaning and word structure are known to influence text difficulty (Fitzgerald et al., 2015) and including a random intercept over story elements allowed for these differences to be taken into account. The models were fit with the glmer-function in the lme4-package (Bates, Maechler, Bolker, & Walker, 2014) in R (R Core Team, 2014). Likelihood ratio tests were used to test whether a certain main effect or interaction effect was a significant addition to a model by statistically testing the improvement in model fit (log-likelihood) of the more complex model containing that effect compared with the simpler model without that effect (Jaeger, 2008). All hypothesis tests were based on a Type I error probability of .05. Mean proportions correct recall for each story-element characteristic are provided in Table 2.

TABLE 2
Mean Proportions Correct Recall as a Function of Type and Importance of Story Elements and Age

	Age		
Story Element	*8–10 Years*	*13–15 Years*	*19–21 Years*
Social-cognitive processing demands			
Nonsocial story elements	.50	.58	.62
Social story elements	.23	.30	.50
Importance			
Less-important story elements (≤3 connections)	.47	.41	.52
Important story elements (≥4 connections)	.35	.48	.59

RESULTS

In this section we report the model-building steps, followed by the interpretation of effects in the final model. With regard to model selection, we first investigated story-element characteristics and their possible interactions. Social-cognitive processing demands and structural importance may both influence recall, but the influence of social-cognitive processing demands may differ depending on whether a story element is important for the causal structure of the text or not. Second, we added person characteristics. Reading comprehension develops with age, and age differences could therefore influence recall. Following a similar rationale we also included gender.[1] Finally, interactions between story-element characteristics and person characteristics were included, as this enabled us to examine the effects of both age-related differences and gender-related differences in the effects of both social-cognitive processing demands and structural importance on narrative recall.

To account for individual differences in the ability to recall story elements and to account for differences in story-element difficulty, random person intercepts and random intercepts for story element were included in the most basic model (Model 0). The random and fixed effects included in each model and model fit statistics are displayed in Table 3. Likelihood ratio tests involved comparison with the models in the nested model column. There were no missing data.

Story-Element Characteristics

To investigate whether characteristics of story elements improve the prediction of story-element recall, we first added the factors social-cognitive processing

[1]Gender alone or in interaction with story-element characteristics did not significantly contribute to the prediction of story-element recall and is therefore not included in the main text describing the model-building steps.

TABLE 3
Model Comparison

Model	*Tested Against*	*Fixed Effects*	*−LL*	*Number of Parameters (K)*	*LR Test*	
					χ^2 *(df)*	*p*
M0			−1022.5	2		
M1a	M0	+ SCP demands	−1020.5	3	4.13 (1)	.04*
M1b	M0	+ Importance	−1022.5	3	.00 (1)	.95
M1c	M1a	+ SCP demands + Importance	−1020.4	4	.04 (1)	.84
M1d	M1c	+ SCP demands : Importance	−1019.8	5	1.36 (1)	.24
M2a	M1c	+ Age group	−1008.0	6	24.95 (2)	<.001***
M3a	M2a	+ SCP demands : Age group	−1001.7	8	12.51 (2)	.002**
M3b	M2a	+ Importance : Age group	−1002.2	8	11.59 (2)	.003**
M3c	M3a	+ Importance : Age group	−996.5	10	10.37 (2)	.006**
M3d	M3c	+ SCP demands : Age group : Importance	−995.3	13	2.51 (3)	.47

Note: All models contain a random intercept over persons and a random intercept over story elements. LR tests involve comparison with the models in the Tested Against column. -LL = log likelihood; LR test = likelihood ratio test; SCP demands = social-cognitive processing demands; ' + factor' represents the inclusion of the main effect of the factor on the dependent measure besides the effects that were included in the previous (Tested Against) model; 'factor A : factor B' represents the interaction effect of the factors on the dependent measure.
*Significant with $p < .05$; **significant with $p < .01$; ***significant with $p < .001$.

demands (Model 1a) and importance (Model 1b) to Model 0. Social-cognitive processing demands (nonsocial, social) significantly predicted recall of story elements, $p = .04$. Overall, the probability of correctly recalling story elements was lower for social story elements than for nonsocial story elements (Table 2). Importance (≤ 3 connections, ≥ 4 connections) did not significantly predict recall of story elements, alone ($p > .05$) or when added to the model with social-cognitive processing demands (Model 1c), $p > .05$. Furthermore, the interaction between social-cognitive processing demands and importance (Model 1d) was not significant, $p > .05$; therefore this interaction was not taken into account in further analyses. To further explore all possible interactions of the two text characteristics (social-cognitive processing demands and importance) with person characteristics (gender and age), model building is continued with Model 1c, which includes the main effects of the text characteristics.

Person Characteristics

Adding age group (with categories 8–10 years, 13–15 years, and 19–21 years) to the model (Model 2a) significantly improved model fit, $p < .001$. Overall, the probability of correctly recalling story elements increased with age (Table 2).[2]

Story-Element Characteristics and Person Characteristics[3]

The interaction between social-cognitive processing demands and age group (Model 3a) resulted in a significant improvement in model fit, $p < .002$, as did the interaction between importance and age group (Model 3b), $p = .003$. Adding the importance-by-age-group interaction to the model containing the social-cognitive-processing-demands-by-age-group interaction resulted in a significant improvement in model fit (Model 3c), $p = .004$, so each interaction made a significant, unique contribution to the model. The three-way interaction between social-cognitive processing demands, age group, and importance (Model 3d) did not significantly improve model fit, $p > .05$. As the three-way-interaction did not further improve model fit, Model 3c was chosen as the final model.

Final Model

The final model (Model 3c) included the main effects of social-cognitive processing demands, importance, and age group as well as the interactions

[2]Model fit was not significantly improved by adding gender to the model, $p > .05$, and when age group was taken into account gender also did not add to the prediction of story-element recall, $p > .05$.

[3]Adding the interaction between social-cognitive processing demands and gender or the interaction between importance and gender did not improve model fit significantly, both p's $> .05$.

between social-cognitive processing demands and age group and between importance and age group. To facilitate the interpretation of results, the logistic regression parameters were rescaled to estimated proportions or probabilities of correct recall for an average person on an average story element. From this final model we can conclude that the probability of correctly recalling a story element can be predicted from the interaction between social-cognitive processing demands and age group together with the interaction between importance and age group. Figure 2 shows the estimated probabilities of correctly recalling a story element from this final model.

Post hoc analyses of the interaction effects revealed that the effect of social-cognitive processing demands on recall, for important-, and less-important story elements combined, was significant for the 8- to 10-year-old children ($b = -1.44$, $z = -2.67$, $p = .008$) and 13- to 15-year-old adolescents ($b = -1.37$, $z = -2.56$, $p = .01$) but not for the 19- to 21-year-old adults ($b = -0.61$, $z = -1.15$, $p = .25$). For both 8- to 10-year-old children and 13- to 15-year-old adolescents the probability of correctly recalling nonsocial story elements was higher than the probability of correctly recalling social story elements. Story elements that require social-cognitive processing were more difficult to recall than story elements that did not require social-cognitive processing (Figure 2a). As for the age-related differences in correctly recalling story elements with different social-cognitive processing demands, the results showed that between 13–15 and 19–21 years the probability of correctly recalling social story elements increased significantly faster than the probability of recalling nonsocial story elements ($b = .77$, $z = 2.76$, $p = .005$). Thus, there was a significant difference in developmental trajectories from adolescence to adulthood between story elements that required social-cognitive processing and those story elements that did not require social-cognitive processing. Between ages 8–10 and 13–15 years there was no difference between the increase in the probability of correctly recalling nonsocial story elements and the increase for social story elements ($b = .07$, $z = .23$, $p > .05$).

In addition, although there was no significant main effect of importance in any of the age groups for recall of social and nonsocial story elements combined (8–10 years: $b = -.49$, $z = -.86$, $p = .39$; 13–15 years: $b = .46$, $z = .81$, $p = .42$; 19–21 years: $b = .32$, $z = .57$, $p = .57$), there were significant differences in the age-related differences in recall for important and less-important story elements, respectively, between 8–10 and 13–15 years, $b = .96$, $z = 2.98$, $p = .003$. This interaction reflects different directions of change for the important and less-important elements, respectively (Figure 2b). The direction of change from age 8–10 to 13–15 for recall of less-important story elements (a relative decline) differed from that for important story elements (a relative increase). Between ages 13–15 and 19–21 years there was no difference between the developmental trajectories: The change in the probability of correctly

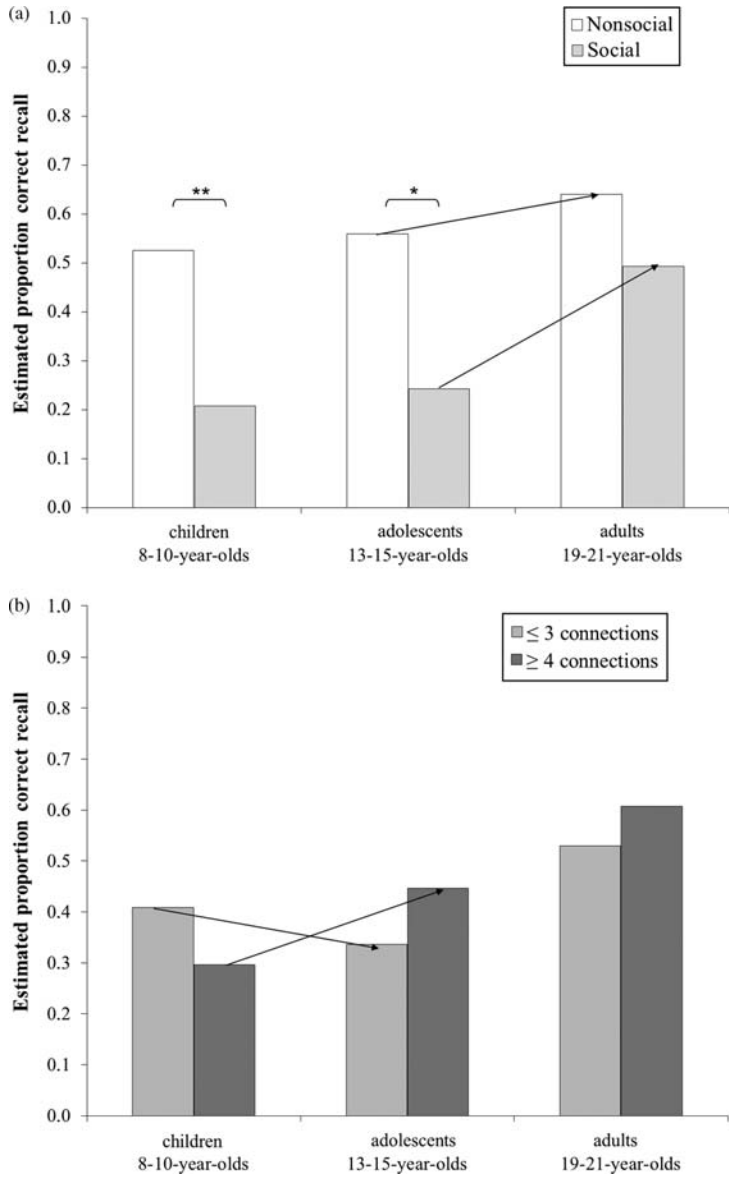

FIGURE 2 Estimated probability of correctly recalling story elements for (a) social-cognitive processing demands and (b) structural importance, as a function of age group for an average person on an average story element. The arrows represent the subset of developmental trajectories that differ significantly between social and nonsocial elements (a) and between more (≥ 4 connections) and less (≤ 3 connections) important elements (b). *Significant with $p < .05$; **significant with $p < .01$.

recalling less-important and important story elements was similar between ages 13–15 and 19–21, $b = .14$, $z = .47$, $p > .05$.

DISCUSSION

This study examined the effects of social-cognitive processing demands and of differences in the structural importance of story elements on narrative recall by children, adolescents, and adults. We used a GLMM approach to examine whether reader characteristics and text characteristics influenced recall of a narrative text. Inclusion of random intercepts for both participants and story elements allowed for investigating multiple story elements that were nested within each subject as well as accounting for variance due to general differences between story elements. The results indicate that the combination of reader characteristics (age group) and text characteristics (social-cognitive processing demands and importance) is an important predictor of the probability of correctly recalling story elements.

The results showed that the probability of correctly recalling story elements increased with age. This main effect was qualified by an interaction with both importance and social-cognitive processing demands of the story-element. Between age groups the effect of social-cognitive processing demands on story-element recall differed: 8- to 10-year-old children as well as 13- to 15-year-old adolescents were significantly less likely to recall social story elements than nonsocial story elements. This resulted in differences in overall recall of the text by children and adolescents compared with that by adults. These differences were most apparent for those aspects of the story that required social-cognitive processing. For social-cognitive processing demands age-related differences manifested themselves relatively late: Recall of social story-elements increased substantially between adolescence and adulthood. The findings suggest that the development of social-cognitive abilities contributes to the ability to construct a rich mental representation of a text that encompasses social-cognitive aspects of the story. In contrast, for sensitivity to structural centrality age-related differences manifested themselves earlier between childhood and adolescence.

The effect of structural importance manifested itself at a younger age than the effect of social-cognitive processing. Age-related differences manifested themselves between childhood and adolescence as reflected in the different directions of change for the developmental trajectories for important-, and less-important story elements, respectively, between ages 8–10 and 13–15 years. Thus, sensitivity to structural centrality reached adult levels at age 13. In contrast, recall of social story elements differed between adolescents and young adults, with only the latter being more likely to incorporate social elements in their mental representation of the text. This finding shows that in our sample,

comprehension of social-cognitive information continued to develop after age 15, consistent with findings that social cognition continues to develop throughout childhood and adolescence (e.g., Blakemore, 2008). Thus, 13- to 15-year old adolescents behave like adults with respect to sensitivity to structural centrality but behave more like children with respect to comprehension of social story elements. These findings support the hypothesis that immature social-cognitive abilities in childhood and adolescence limit processing of story elements that contain social-cognitive information and, as a consequence, will have a negative effect on recall of these social story elements by children and adolescents.

The relatively late development of understanding of social aspects of narratives is in line with the results from a wealth of studies in the field of developmental-cognitive neuropsychology concerning the development of the brain regions that support social-cognitive processing. These results indicate that social-cognitive processes and the brain regions that underlie these processes show relatively protracted developmental change (e.g., Blakemore, 2008; Mills et al., 2014). Interestingly, some of these neuroimaging studies have used narratives as stimulus materials. For example, Saxe, Whitfield-Gabrieli, Scholz, and Pelphrey (2009) asked 6- to 11-year-old children to listen to prerecorded stories describing physical facts, a character's social relations or appearance, or the character's mental state. They found that two brain regions that are crucial for social cognition, the right temporoparietal junction and the medial prefrontal cortex, show different patterns of activation in children and adults, respectively. With age the specificity of the temporoparietal junction for mental states increases: In children this region is recruited equally for descriptions of characters' appearance and for characters' mental state (Saxe, Whitfield-Gabrieli, Scholz, & Pelphrey, 2009), whereas in adults the right temporoparietal junction is selectively recruited for mental states. Similarly, when processing social information about others activation of the medial prefrontal cortex decreases with age. Children recruit this area when processing social information about others, whereas adults do not. Finally, in 11- to 16-year-old adolescents, processing of cartoons that require inferences about how the protagonist would react to the other character's emotional state (affective theory of mind) elicited more activation in the left ventromedial prefrontal cortex than cartoons in which it was not necessary to infer the mental states of the characters. This difference was not observed in 24- to 40-year-old adults (Sebastian et al., 2012). These findings show that the neural mechanisms underlying social-cognitive processing and theory of mind specialize and mature relatively late, during childhood and adolescence (Saxe et al., 2009; Sebastian et al., 2012).

The notion that there is continued development of processing of social-cognitive information in narratives resembles the results of various behavioral studies using various comprehension tasks and methodologies. It is crucial to understand the mental state of the story character to infer a character's goal or to

know why actions in a story take place (Emery, 1996). After all, readers generate causal inferences based on the character's goals (Trabasso, 2005). Children do not yet focus on the character's mental states that are essential for story comprehension. This is reflected in the fact that younger readers aged 9–11 tend to focus more on what happens in a story than on why things happen when asked to recall a story (Stein & Levine, 1990, as described in Emery, 1996). Furthermore, in contrast to undergraduate students, 11-year-old children show difficulties with recalling the character's motive after hearing or listening to a short fable and are less able to answer questions requiring inferences about the character's motive (Shannon, Kame'enui, & Baumann, 1988). Finally, when asked to choose an appropriate ending after looking at three cartoon frames, 24- to 40-year-old adults were better able to infer how the story character would react to the other character's emotional state and, thus, correctly predict the ending than were 11- to 16-year-old adolescents (Sebastian et al., 2012).

The results of these neuroimaging and behavioral studies support the conclusion based on the current results that limited social-cognitive abilities in children and adolescents may result in difficulties in processing and recalling text information that requires social-cognitive processing. It may also explain problems that children in fourth grade show with inferences regarding the main character's traits, feelings, beliefs, and motivations as pointed out by the PIRLS results (Mullis et al., 2012). Between ages 13–15 and 19–21 years the increase in the probability of correctly recalling social story elements was significantly larger than that of nonsocial story elements, eventually leading to similar recall of story elements that require social-cognitive processing and those that did not in adulthood, whereas children (8–10 years) and adolescents (13–15 years) do show difficulties with processing these aspects of a narrative. The results highlight the importance of social-cognitive abilities for reading comprehension in developing readers.

The finding that social-cognitive development restricts comprehension of social story elements has potential implications for reading comprehension research when studying narratives in children and adolescents, as the age-related changes in reader characteristics should be taken into account. In adults, reading fiction has been shown to enhance social-cognitive ability: After reading literary fiction, participants' theory of mind performance as measured with a false-belief task and the reading-the-mind-in-the-eyes test increased (Kidd & Castano, 2013). This finding could have implications for social-cognitive development as well. For example, more than one-third of the books for young children contain information about mental states that can act as a source for learning to understand other people's minds and for developing social-cognitive abilities (Dyer et al., 2000). Whereas both children's books for 3- to 4-year-old and those for 5- to 6-year-old children contain information about mental states, the frequency and variety of this information is larger in books for 5- to 6-year-old children.

Our findings together with the recent research pointing to adolescence as an important time for the development of social-cognitive abilities suggest that narratives can have an important role in the development of social-cognitive abilities for much longer than was previously thought.

One factor that deserves attention is that in adolescence motivation for reading and the amount of leisure time reading tend to decline (Clark & Douglas, 2011). For example, 7- to 11-year-old children (U.S. grades 2–6) report to enjoy reading more than 11- to 16-year-old children (U.S. grades 6–11). Likewise, 7- to 11-year-old children (U.S. grades 2–6) state to read more often than 11- to 14-year-old adolescents (U.S. grades 6–9) who, in turn, report to read more often than 14- to 16-year-old adolescents (U.S. grades 9–11) (Clark & Douglas, 2011). Similarly, self-reported intrinsic motivation for reading decreases between ages 11 and 13 (Unrau & Schlackman, 2006). Finally, print exposure has been found to be positively related to reading comprehension ability in primary and middle school (Mol & Bus, 2011). The decline in leisure time reading in adolescence is worrisome, not only because of its relation with the development of reading comprehension and, therefore, with academic success but also because of the possible role of reading experience in the development of social-cognitive abilities.

A limitation of the current study is that only one narrative text was analyzed; hence, there is a possibility that the findings originate from characteristics of this specific narrative. The text was suitable for the youngest group in terms of the topic, wording, and technical reading level to prevent that textual demands unduly burdened decoding and related skills of the youngest readers and to allow us to examine the subtle effects of social-cognitive development on reading comprehension in a context in which all readers were able to construct a coherent mental representation. We used the same text for all age groups to avoid a possible confound of differences in text content. As a result, an alternative interpretation of our findings could be that participants in the older groups outperformed those in the younger groups because the narrative was easier for them, allowing them, for example, to read the story twice.

However, we instructed participants to indicate to the experimenter when they had completed the story. The resulting reading times suggest that the superior recall performance of the young adult group is not due to reading the story multiple times: Reading times decreased with age and for each age group were similar to what has been found in prior research by means of computerized or eye-tracking methods that preclude rereading. Furthermore, because previous research findings indicate that the basic process that underlie the creation of a mental model are similar in children and adults (Oakhill, & Cain, 2004; Van der Schoot, Reijntjes, & Van Lieshout, 2012), we expect that the effects of social-cognitive processing demands would be similar in a more difficult narrative. Even in the current, relatively easy narrative adult readers require sufficient

social-cognitive processing abilities to include information about characters in the emerging mental representation during reading. A strength of the present study is that we used a within-subjects design; therefore, differences between age groups, such as age-related differences in working memory capacity, are unlikely to explain the results. Any such differences would have affected the recall of both social and nonsocial story elements. In addition, we analyzed multiple sentences derived from the text. These included sentences that required social-cognitive processing and sentences that did not as well as sentences that were important and sentences that were less important for the causal structure of the text. Thus, there were multiple stimuli for each participant, even though there was only one text. Nevertheless, a replication using multiple texts, as well as texts that vary in difficulty, would be advantageous for the generalizability of the current findings.

A second limitation is that the participants in all age groups in this study were relatively well educated. Particularly with regard to educational implications it would be relevant to collect similar data from populations less educated, less familiar with reading, or with fewer reading skills. Future directions of this line of work could establish whether individual differences in social-cognitive abilities predict recall by specifically measuring social-cognitive ability using tasks such as the Director Task (Dumontheil et al., 2010), the Interpersonal Reactivity Index (Davis, 1980), or the Frith-Happé animations (Abell et al., 2000).

To conclude, our findings suggest that as social-cognitive abilities develop, so does the ability to understand social information in narratives and the ability to incorporate this information in a coherent mental representation of the text. This fits well with cognitive models of comprehension that stress the need to consider the influence of social-cognitive processing on narrative comprehension because narrative comprehension often depends on understanding and representing the thoughts, needs, goals, and actions of story characters (e.g., Graesser, Singer, & Trabasso, 1994). Our findings are an important initial step toward bringing together psycholinguistic research on social-cognitive inferences and research on the development of social cognition and, in doing so, point to the important role of the interaction between reader characteristics, including social-cognitive skills, and text characteristics in reading comprehension.

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