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The effects of updating ability and knowledge of reading strategies on reading comprehension

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ABSTRACT

Updating ability and reading strategies are considered as important factors in the buildup of a mental model of a text. However, only few studies examined the relation of updating and knowledge of reading strategies with reading comprehension. The aim of the current study was to investigate the specific effects of updating ability and knowledge of reading strategies on reading comprehension, controlling for reading speed, vocabulary, and short-term memory. One-hundred-and-ninety-five Dutch fourth graders were administered two standard Dutch reading comprehension tests, and measures of updating ability, knowledge of reading strategies, reading speed, vocabulary, and verbal short term memory. The results showed that updating ability did not contribute to reading comprehension, when other predictors were controlled, whereas knowledge of reading strategies had an independent effect on reading comprehension. The relations of updating ability and knowledge of reading strategies, as well as those of other predictors, with reading comprehension were similar across the two reading comprehension tests.

1. Introduction

Text comprehension is a complex cognitive activity (Rapp & van den Broek, 2005). Abundant evidence shows that the comprehension of a text is dependent on word decoding and general language skills, such as vocabulary knowledge (e.g., Hoover & Gough, 1990, Verhoeven & Perfetti, 2008). Beyond these foundational skills, more general cognitive and metacognitive processes are involved. In the current study we focused on the relationships of updating ability and knowledge of reading strategies with individual differences in reading comprehension.

Understanding a text requires the buildup of various representations (Kintsch, 2012). The surface representation includes the form of words and their syntactic relations. The textbase consists of the meaning of words and connections between sentences. The situation model is a coherent representation of the situation described in the text. Several models of reading comprehension suggest that the process of text comprehension, especially the construction of a situation model, is related to updating (Gernsbacher & Foertsch, 1999; Kintsch, 2012; van den Broek et al., 1996; Zwaan, Langston, & Graesser, 1995). For example, in the construction-integration model updating can be considered as the integration of knowledge from the textbase with readers' prior knowledge (Kintsch, 2012). The subsequent activation of concepts in the landscape model and the refinement of their interconnections might also be seen as un updating process (van den Broek et al., 1996). The event indexing model assumes that the comprehension of an event in the text is associated with the monitoring and updating of the situation model on a number of indices (i.e., temporality, spatiality, protagonist, causality, and intentionality) (Zwaan, et al., 1995). For example, if an event indicates a time shift in the story, then the temporal index of the situation model will be updated. The structure building model describes that during mental model building, the building blocks of the structure (i.e., memory nodes) are activated or suppressed, depending on whether the information they represent is necessary for further structure building (Gernsbacher & Foertsch, 1999). This process of enhancing or suppressing activation of memory nodes might be seen as updating.

In addition to updating, inferences are generally assumed to be important for the construction of a situation model (Cain & Oakhill, 1999). Such a model does not only consist of information stated explicitly in the text, but also depends on inferences that go beyond the text, being the result of an interplay between information in the text and readers background knowledge (Zwaan & Radvansky, 1998). Which inferences are generated is determined by the readers' goal and by coherence and explanation strategies (Graesser, 2007). Individual differences in reading comprehension might therefore depend on the knowledge and use of such strategies. Indeed, a major method to foster inference making, and thereby reading comprehension, is the training of reading strategies (e.g., Brand-Gruwel, Aarnoutse, & van den Bos, 1998; Spörer, Brunstein, & Kieschke, 2009).

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Theoretically, updating ability and the availability or knowledge of reading strategies are considered important for text comprehension. However, there are few studies in which their relationship with reading comprehension has been examined in a sample of typically developing children (e.g., Cain, 1999).

1.1.. Updating

Updating during reading comprehension is the process of incorporating new information into the existing mental model (Zwaan & Radvansky, 1998), or more generally, modifying the current representation of information in memory to hold new information (Morris & Jones, 1990). Updating is assumed to be one of the components of the central executive system of working memory (Miyake, Friedman, Emerson, Witzki, & Howerter, 2000; van der Sluis, de Jong, & van der Leij, 2007). Numerous studies have shown that working memory is involved in reading comprehension (Cain, Oakhill, & Bryant, 2004; Daneman & Merikle, 1996). However, most of these studies involved broader measures of working memory, such as complex span tasks, and did not concern updating proper (Carretti, Borella, Cornoldi, & de Beni, 2009).

Palladino, Cornoldi, de Beni, and Pazzaglia (2001) were among the few who considered updating in relation to reading comprehension. In their first experiment, poor and good adult comprehenders were asked to recall the last four words from auditory presented lists of unknown length. Poor comprehenders performed more poorly on this task than good comprehenders. However, because most participants reported that they did not update at all, but just recalled the last words they had heard, task performance seemed to depend mostly on recency effects (Elosúa & Ruiz, 2008; Palladino & Jarrold, 2008). Therefore, in a second experiment, Palladino et al. (2001) administered a task with a semantic criterion, thereby rendering some of the stimuli to be irrelevant. In this task, the last three or five smallest items of the list had to be recalled. This criterion necessitates updating, because the last items were not necessarily the smallest ones. Also with this modified updating task, Palladino et al. found that the poor comprehenders performed worse than the good comprehenders.

Carretti, Cornoldi, de Beni, and Romanò (2005) argued that the semantic criterion used by Palladino et al. (item size) was ambiguous, since the size of objects is not fixed. For example, a suitcase might be considered both smaller and bigger than a television. Therefore, Carretti et al. (2005) used a different updating task with an objective criterion: the place of an item in a row. However, an updating task with a semantic criterion seems to be a better reflection of the updating process during reading comprehension than an updating task with item place as criterion.

The first aim of the current study was to investigate the relationship between updating ability and reading comprehension. For the updating task, we used an unambiguous semantic criterion, the selection of animals or body parts from series of words. Filler items were added to the series to avoid recency effects (Elosúa & Ruiz, 2008; Palladino & Jarrold, 2008). Unlike previous studies that focused on poor and good comprehenders, we investigated the relationship between updating and reading comprehension in an unselected sample of typically developing children.

1.2. Reading strategies

Reading strategies are generally believed to facilitate text comprehension (Graesser, 2007). Various types of measures of reading strategies can be distinguished. One type requires the use of a particular reading strategy during passage reading which is followed by comprehension questions (e.g., Spörer et al., 2009). A disadvantage of this measure is that it remains unclear whether strategies are used correctly if not explicitly instructed. In a metacognitive awareness inventory of reading strategies, another type of measure, participants have to report how often they use particular reading strategies during reading (Cantrell, Almasi, Carter, Rintamaa, & Madden, 2010; Mokhtari & Reichard, 2002). Unfortunately, strategies are often used automatically and unconsciously. Therefore, it seems difficult to report about how often these strategies are used (Cromley & Azevedo, 2006). Indeed, Cromley and Azevedo did not find a relationship of such a questionnaire with reading comprehension. In this study we focused on knowledge of reading strategies (Gruwel & Aarnoutse, 1995). We made a distinction between knowledge of how to clarify parts of the text that are incomprehensible for the reader and how to control and evaluate the reading process (see also, Cross & Paris, 1988).

1.3. Present study

This study focused on two core factors related to the construction of a situation model, updating ability and knowledge of reading strategies. To examine their specific effects on reading comprehension, we controlled for foundational skills as word reading speed and vocabulary (Verhoeven & Perfetti, 2008). Several studies have shown that the relationship of various cognitive abilities with reading comprehension can differ across tests (Andreassen & Bråten, 2010; Keenan, Betjemann, & Olson, 2008; Kendeou, Papadopoulos, & Spanoudis, 2012). Therefore, to examine the generalizability of the results, we included two standard reading comprehension tests. We expected both updating ability and knowledge of reading strategies to have a specific positive effect on both reading comprehension tests.

2. Methods

2.1. Participants

Participants were 195 Dutch fourth graders from seven regular elementary schools in the Netherlands of which 82% was native speaker. The sample comprised 102 boys and 93 girls with a mean age of 9;10 years ($SD = 5.89$ months).

2.2. Measures

Measures were selected to investigate updating ability, reading strategies, and reading comprehension. Measures for reading speed, vocabulary knowledge, and verbal short term memory were used as control variables.

2.2.1. Updating ability

Updating ability was measured with a word updating task. Children were required to recall the last two or three target items (animals or body parts) from series of unknown length. All series contained target items and filler items, nouns that are not an animal or a body part. Both the target items and fillers were selected from a list of words commonly known by six-year-old children (Schaerlaekens, Kohnstamm, & Lejaegere, 1999). All target items, 20 animals and 20 body parts, and 40 filler items were monosyllabic concrete nouns. Series were created by randomly selecting four to seven target items for each series. Then, the same number of fillers as target items was randomly selected and added to each series. Zero to two fillers were placed between the target items, so that maximally two target items were consecutive. Series always started with a target item, and ended with one or two fillers. Series comprised two or three target items to be recalled and two to four target items to be updated, which resulted in list lengths between eight and 14. The task was programmed in E-Prime version 2.0 (Schneider, Eschman, & Zuccolotto, 2010). Series were presented auditorily in a fixed order with a speed of one word per two seconds. To fixate the attention of children at the start of each series, the children were told that the next series would start. At the end of each series, children had to recall the target words verbally. The answer was registered on a scoring sheet. There were 16 series in total, part one consisted of eight series with animals as target items and part two comprised eight series with

body parts. Each part started with four items in which two words had to be recalled with list lengths of respectively eight, 10, 12, and 10. For example, an item where children had to recall the last two animals was: *dog*, *bread*, *cat*, *pear*, *monkey*, *cheese*, *lion*, *sweets*. The correct answer was *monkey* and *lion*. Then, four items which consisted of three target items were presented, with list lengths of respectively 10, 12, 14, and 12. Before the start of part one of the test, children were taught how to update. The first three practice items were carried out without the laptop. The first practice item was a series of three animals without fillers. Children were asked to recall the last two animals. The second and third practice item consisted of series of animals and fillers from which children had to recall the last two animals. The fourth and fifth practice items were comparable to previous ones, but these were carried out on the laptop. For the fifth practice item, children had to recall the last three animals. The answers on each practice item were explained by showing the series on paper. Before the start of part two of the test, there were two practice items on the laptop. The score was the number of correctly recalled series. The split-half reliability (animals versus body parts) was .60.

2.2.2. Knowledge of reading strategies

To assess knowledge of reading strategies, an adapted version of the Reading Comprehension Questionnaire of Gruwel and Aarnoutse (1995) was used. This questionnaire contained questions about what to do before, during, and after reading a text (e.g., "While reading the best thing I can do is …"), questions about monitoring the reading process (e.g., "How can I check whether I comprehend a text?"), and questions about strategies that can be used when one does not comprehend a word or a part of the text (e.g., "What can I do best if I do not understand the text anymore?"). Due to time constraints, we omitted five questions concerning strategies before reading. An example question is: "If I do not understand a sentence, the best thing I can do is … a) Look at the picture; b) Count the number of sentences I read; c) Read the sentence again, slowly; d) Transcribe the sentence". Each question was followed by four response alternatives. The test consisted of 25 questions, preceded by three example questions. The score was the number of questions answered correctly. Cronbach's alpha was .79.

2.2.3. Reading comprehension

Reading comprehension was assessed with two standard Dutch reading comprehension tests. The LOVS test (*Leerling- en Onderwijs Volgsysteem*, [*System for the Longitudinal Assessment of School Achievement*]) is a standardized test for first to sixth graders, regularly used in Dutch education (Cito, 2008; *Centraal Instituut Toetsontwikkeling*, [*Dutch National Institute for Assessment in Education*]). In this study, the LOVS for fourth-graders was used. Also, the CLIB test was administered, another (nationally normed) standard Dutch test for reading comprehension. We used version 4A for fourth graders (Cito, 1992). The manuals state that the tests contained questions requiring inferences between parts of the text and questions that require inferences between parts of the text and background knowledge, such as a summarizing question or a question where a title of the text has to be chosen (Cito, 1992, 2008). In the CLIB, all questions require inference making. In the LOVS one-fifth of the questions are literal, and the rest of the questions require inferences.

2.2.3.1. LOVS. The LOVS consists of three parts, with five texts each. The test is partly adaptive to the level of reading comprehension of the child (Cito, 2008). All children finished a first part and then, depending on their score on the first part, continued with an easier or more difficult second part. The texts of the first part had between 108 and 709 words. The texts of the two second parts ranged from 102 to 468, and from 189 to 588 words, respectively. All parts contained both narrative and expository texts. Each part consisted of 25 multiple choice questions: question-and-answer (Q&A) and cloze items. Cloze items are gap-filling questions. Both items had four alternative answers. An example item is: "Which title fits best with the text? a) Famous animals; b) Dangerous creeps; c) Exciting comics; d) Cool drawers". The first and easier second part contained 36% cloze items. Of the first and more difficult second part, 24% was a cloze item. The texts were continuously accessible. Each part took approximately 45 minutes to finish. For the analyses, the standard ability score of the test was used, which is based on item response theory (Cito, 2008) and is an indication of the level of reading comprehension irrespective of which second part was administered. Cronbach's alpha was .75 both for the first and easier second part as for the first and more difficult second part.

2.2.3.2. CLIB. The CLIB contains seven different expository texts ranging from 136 to 1044 words. The test consists of 30 cloze items with five alternatives (Cito, 1992). Due to time limitations, not all children were able to finish all 30 items. Thus, instead of using the raw score, the proportion score was computed and multiplied by 30, which resulted in an estimation of the total number of items correct. Calculated for children without missings, which was 77% of all children), the reliability of the CLIB was sufficient ($\alpha = .79$).

2.2.4. Reading speed

Reading speed was measured with a word and a pseudoword reading task.

2.2.4.1. Word reading task. The one-minute word reading task is a standard Dutch test which is often used to measure the level of reading speed in primary school children. Children were asked to read as many words correct as possible in one minute from a list of 116 words of increasing difficulty (Brus & Voeten, 1979). The words had one to five syllables. The score was the number of words read correctly in one minute. According to the manual, mean parallel-test reliability was $r = .90$ (between form A and B) (van den Bos, lutje Spelberg, Scheepstra, & de Vries, 1994).

2.2.4.2. Pseudoword reading task. The pseudoword reading task is a standard Dutch test which is often used to investigate reading speed in elementary school children. Children were instructed to read as many pseudowords correct as possible in two minutes. The task consisted of a list of 116 pseudowords of increasing difficulty (Klepel; van den Bos et al., 1994). The pseudowords had one to five syllables. The score was the number of pseudowords read correctly in two minutes. According to the manual, mean parallel-test reliability was $r = .92$ (between form A and B).

2.2.5. Vocabulary knowledge

A synonyms task was used to measure vocabulary knowledge. Each item of the task consisted of a word with five possible synonyms. Children were required to read each word and the possible corresponding synonyms and to circle the correct synonym matching each word on a scoring sheet. The synonyms task consisted of 20 items. Before the start of the test, two practice items were given. The score was the number of correctly chosen synonyms. The split-half reliability (for even and odd items) was .63.

2.2.6. Verbal short term memory

A word span task was used to measure verbal short term memory. Children were required to recall series of words, consisting of the nine concrete nouns that served as fillers on the updating task. The series were programmed in E-Prime version 2.0 (Schneider et al., 2010), and presented auditorily on a laptop with a speed of one word per second. After each series, children were asked to recall the words in the same order as presented. The task comprised series of two to nine words. There were three series per list length. The task was stopped when children failed on all series of the same list length. Before the start of the

test, there were three practice items consisting of two words, from which the first two were presented auditorily and the last one on the laptop. The score was the number of correctly recalled series.

2.3. Procedure

The LOVS test was administered by the teacher. The CLIB, strategy questionnaire, and the vocabulary task were assessed in one session in class. The tasks for updating, short term memory, and reading speed were administered individually.

3. Results

3.1. Data preparation

Seven children, who had missings on more than half of the tests, were removed. In the remaining sample of 188 children two outlier scores (more than three standard deviations below or above the mean), on the word span task and the LOVS, were considered as missing. In all 5% of the scores was missing. Little's MCAR test revealed that data were missing at random (predictors: χ^2 (26) = 29.71, p = .28; reading comprehension tests: χ^2 (2) = 1.52, p = .47). In order to be able to use all participants in the analyses, missing scores were estimated using the EM method (Tabachnick & Fidell, 2013).

3.2. Preliminary analyses

Descriptive statistics of all variables are reported in Table 1. Scores were normally distributed with skewness and kurtosis values within acceptable ranges.

To test whether the updating test is a measure of updating and not merely reflects recency effects (Elosúa & Ruiz, 2008), we examined whether there are delayed intrusion errors (Palladino et al., 2001): that is, recall of target items that should have been updated already. Table 2 shows that around half of the errors children made were delayed intrusion errors. We also examined whether the proportion of correctly recalled words is affected by the number of updates and the number of words to be recalled increases. An ANOVA with number of recalls (2 or 3) and updates (2 to 4) as within subject factors revealed a main effect of number of updates (F(1.91, 352.56) = 16.24, p < .001) and number of recalls (F(1, 185) = 379.99, p < .001). As expected, the higher the number of updates, and the higher the number of recalls, the lower the number of correctly recalled words. The interaction between number of updates and recalls was also significant (F(2, 370) = 6.87, p < .001). Contrasts showed that for items with two and three recalls, the number of correctly recalled words was higher for items with two updates than for items with three updates (F(1, 185) = 4.02, p = .05; (F(1, 185) = 23.31, p < .001) (see Figure 1). Items with three and four updates did not differ in the number of words correctly recalled.

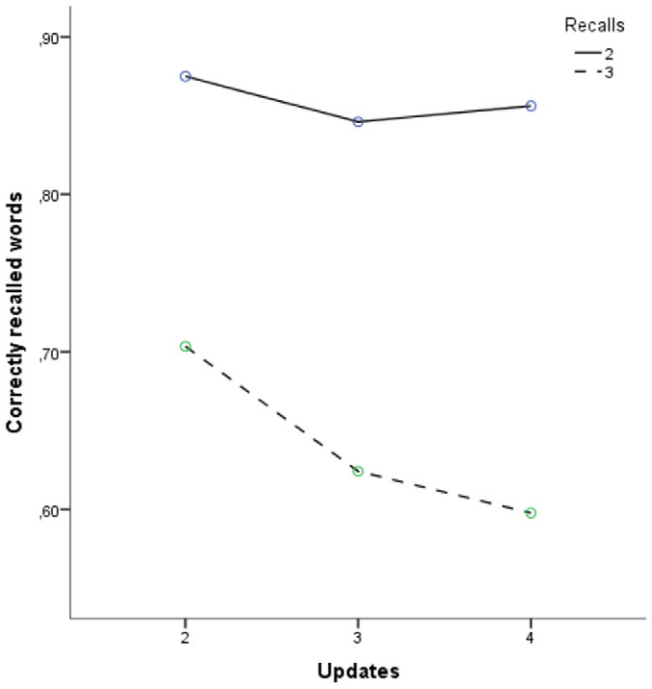

Figure 1. Proportions of the Correctly Recalled Words for the Different Numbers of Updates and Recalls.

Correlations among the variables are presented in Table 3. There was a weak, but significant positive correlation between updating and reading comprehension. Knowledge of reading strategies and comprehension were moderately correlated. The relations of all predictors with reading comprehension were similar for the LOVS and the CLIB.

Since the word reading and pseudoword reading task were strongly correlated, scores on these tasks were standardized and averaged. This composite score was used in further analyses.

Table 1
Descriptive Statistics for Reading Speed, Vocabulary Knowledge, Verbal Short Term Memory, Updating Ability, Knowledge of Reading Strategies, and Reading Comprehension.

	Maximum	*M*	*SD*	Range	Skewness	Kurtosis
Word reading	116	63.81	13.54	33–66	−0.11	−0.54
Pseudo word reading	116	57.83	16.71	15–100	−0.02	−0.31
Vocabulary knowledge	20	9.93	2.65	3–17	0.06	−0.23
Word span	24	9.22	1.62	5–14	0.44	0.86
Updating	40	28.98	4.47	17–39	−0.35	−0.27
Knowledge of reading strategies	25	14.53	4.65	4–25	−0.01	−0.54
LOVS test	121[a]	28.98	11.68	1–60	0.04	0.08
CLIB test	30	13.68	5.35	2–26	0.21	−0.63

[a] The standard ability score for the LOVS test for fourth graders ranges between −76 and 121. This standard ability score is a rash scale, a nonlinear transformation of the raw test scores. This scale has a large range since it is applicable for the scores of children from first to sixth grade.

Table 2
Mean Proportions and Standard Deviations of the Total Number of Errors and the Delayed Intrusion Errors.

	Two recalls		Three recalls	
	Total errors[a]	Delayed intrusion errors[b]	Total errors[a]	Delayed intrusion errors[b]
Two updates	.13 (.17)	.07 (.13)	.30 (.20)	.13 (.12)
Three updates	.15 (.17)	.09 (.11)	.38 (.17)	.18 (.13)
Four updates	.14 (.19)	.10 (.15)	.40 (.22)	.17 (.17)

[a] Proportion score of the total number of errors: the number of words recalled incorrectly divided by the total number of words.
[b] Proportion score of the number of delayed intrusion errors: the number of delayed intrusion errors divided by the total number of words.

Table 3
Correlations for Reading Speed, Vocabulary Knowledge, Verbal Short Term Memory, Updating Ability, Knowledge of Reading Strategies, and Reading Comprehension.

	1	2	3	4	5	6	7	8
1 Word reading	1							
2 Pseudoword reading	.86**	1						
3 Vocabulary knowledge	.44**	.34**	1					
4 Word span	.19**	.19**	.19*	1				
5 Updating	.16*	.22**	.20**	.32**	1			
6 Knowledge of reading strategies	.40**	.34**	.36**	.12	.16*	1		
7 LOVS test	.37**	.32**	.58**	.22**	.22**	.49**	1	
8 CLIB test	.37**	.27**	.47**	.22**	.20**	.43**	.67**	1

* $p < .05$.
** $p < .01$.

3.3. Effects of the predictors on reading comprehension

To test for the specific effects of updating and reading strategies on comprehension, several fixed order regression analyses were carried out (Table 4). We examined the effects of the predictors for each comprehension test. Reading speed and vocabulary were included in the first step to control for foundational abilities of text understanding. Then, short term memory was added to control for the short term memory component within the updating task. Since we were interested in the specific effects of updating and reading strategies, these variables were added lastly.

As expected, reading speed and vocabulary explained a significant part of the variance in all reading comprehension tests. Neither short term memory, nor updating made a significant contribution. Knowledge of reading strategies however explained a significant part of the variance in reading comprehension after all relevant predictors were controlled. There were no differences between the specific effects of the predictors on the different reading comprehension tests. Vocabulary seemed to be stronger related to the LOVS than to the CLIB, however, the difference between the correlations of vocabulary with the LOVS and the CLIB was not significant. Beta's and proportions explained variance are presented in Table 4.

The influence of updating and reading strategies on comprehension tested in a separate model (R^2 between .21 and .30) was somewhat smaller than the influence of the control variables (R^2 between .26 and .37). In addition, the control variables added significantly to the model with updating and reading strategies (R^2 between .12 and .18).

Table 4
Regression Analyses of the Specific Effects of Updating Ability and Knowledge of Reading Strategies on Reading Comprehension.

	LOVS total		CLIB test	
	ΔR^2	β^b	ΔR^2	β^b
1. Reading speed[a]	.13**	.04	.11**	.07
2. Vocabulary knowledge	.23**	.43**	.14**	.32**
3. Verbal short term memory	.01	.08	.01	.10
4. Updating	.01	.06	.00	.05
5. Knowledge of strategies	.08**	.31**	.06**	.27**
Total R^2	.45		.32	

[a] Reading speed: composite score of word reading task and pseudoword reading task.
[b] Standardized regression coefficients are provided for the final model, including all predictors.
** $p < .01$.

4. Discussion

We examined the relations of updating ability and reading strategies with reading comprehension in an unselected sample of typically developing children. We found that updating did not contribute to reading comprehension, when reading speed, vocabulary, and verbal short term memory were controlled. However, we did find a specific relationship of knowledge of reading strategies with reading comprehension. The relations of the predictors with reading comprehension were similar for both measures of reading comprehension.

Previous studies reported differences between poor and good comprehenders in updating (Carretti et al., 2005; Palladino et al., 2001). Using a similar measure of updating, we found a weak relation between updating and reading comprehension in an unselected sample of typically developing readers. However, the relationship disappeared when more basic abilities were controlled, suggesting the absence of a specific relation between updating and reading comprehension. In these earlier studies differences in vocabulary knowledge were not controlled (Carretti et al., 2005; Palladino et al., 2001). If we excluded vocabulary from the regression models, and only controlled for reading speed and short term memory, then the specific contribution of updating to the LOVS approached significance ($p = .09$). The lack of control for vocabulary in earlier studies, and the use of an unselected sample of typically developing children in this study, might explain the differences between the current results and those of previous studies.

It could be argued that updating tasks, as used in our study, do not measure updating, but merely reflect recency effects. Participants might passively wait until the end of each series and just recall the last items. To avoid recency effects, we inserted filler items within the series and series always ended with one or two fillers (Elosúa & Ruiz, 2008; Palladino & Jarrold, 2008). In addition, analyses showed that a higher number of updates was related to a lower number of correctly remembered words. If children would rely solely on recency effects, the number of updates would not be related to the number of correctly remembered words. The analyses also showed that approximately half of the errors were delayed intrusions. It is unlikely that delayed intrusion errors are made if children perform the task by relying on recency effects. For these reasons it seems likely that performance on the task largely reflected the updating of working memory.

A reason for the weak relation between updating and the LOVS test of reading comprehension might be that the LOVS also contained literal questions. Literal questions do not, in contrast to inferential questions, require updating of the situation model. However, similar results were found for the LOVS and for the CLIB test of reading comprehension that only consisted of inferential questions. Moreover, the results were virtually identical if the LOVS score was based only on the inferential questions[1]. Another reason for the absence of a specific relationship of updating with comprehension might be that the updating process involved in the updating task differs from the updating process required during comprehension. In the updating task, the decision whether new information has to be updated is relatively simple (i.e., Is this an animal or not?). When a child has repeatedly heard that a word belongs to a certain category, the activation of that category might even become automatic (e.g., Baddeley, 1996). In contrast, during reading comprehension, the selection of information to be updated is more complex and usually concerns more complicated exchanges between working memory and long-term memory (e.g., Ericsson & Kintsch, 1995). Thus, the relationship between updating and reading comprehension might be underestimated because the updating process required in the standard updating task is not a proper reflection of the updating processes that occurs during comprehension.

A second major finding was that, as predicted, knowledge of reading strategies contributes to reading comprehension. Previous studies

[1] The results of these analyses are available on request from the first author.

examined the use of reading strategies with measures requiring children to apply strategies while reading (Spörer et al., 2009) or by asking children how often they used particular strategies during comprehension (Mokhtari & Reichard, 2002). In this study, we focused on knowledge of reading strategies (Brand-Gruwel et al., 1998). According to Graessers' constructionist theory of comprehension, strategies determine which inferences are generated during reading and thus influence reading comprehension (Graesser, 2007). The role of reading strategies in comprehension is also confirmed by strategy intervention studies (e.g., Spörer et al., 2009), however, to our knowledge, the relation between knowledge of reading strategies and reading comprehension has never been examined. The results of this study show that knowledge of reading strategies can be considered as an important specific contributor to reading comprehension. This result is in line with the emphasis on strategies in Graessers' constructionist theory and provides support for the training of strategies to enhance reading comprehension.

Another important finding is that the relations of the various predictors with reading comprehension were similar across the two comprehension tests. These tests mainly differed in question format (cloze versus Q&A). Previous studies showed that cloze items depend more strongly on decoding than Q&A items (e.g., Keenan et al., 2008). We did not find that but have to admit that the LOVS is not a pure Q&A measure, but contains some cloze items. However, additional analyses revealed that even with pure measures of cloze and Q&A items, there were no differences. A more likely explanation for the similar relations of reading speed with the two tests is that in previous studies confounding characteristics of the tests were not controlled, for example: the cloze tests consisted of shorter passages than the Q&A tests (e.g., Keenan et al., 2008). All passages in the current tests (LOVS and CLIB) were rather long. Comprehension of shorter passages might rely more on decoding than comprehension of longer passages since the correct decoding of words is more critical for understanding when passages are short (Keenan et al., 2008).

The current study also has some limitations. Firstly, the low reliability of the vocabulary and updating tests might be a problem. The low reliability of the updating test can be an explanation for the absence of a specific effect of updating on comprehension. However, the correlations between vocabulary, updating, and comprehension are comparable with previous studies. A second limitation is that we only used one type of working memory test. We found that updating did not have a specific effect on comprehension. But possibly, complex span tasks, that require more exchange with long term memory, have a specific effect on reading comprehension (Carretti et al., 2009). A third limitation is that our study was confined to fourth graders. It might be important to examine a larger age-range and especially the relation of updating with reading comprehension in adolescents and adults. Possibly, the construction of a situation model plays a larger role in comprehension in adults than in children due to differences in text length and complexity.

In conclusion, we found a weak relationship between updating ability and reading comprehension, which disappeared when other predictors were controlled. This result could suggest that the updating process required in the updating task is not a proper reflection of the updating process during reading comprehension. Knowledge of reading strategies had an independent effect on reading comprehension, suggesting their importance for the construction of a situation model and as a target for interventions to enhance reading comprehension. Finally, we found that the correlates of reading comprehension could be generalized across reading comprehension tests.

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