The relations between lower- and higher-level comprehension skills and their role in

prediction of early reading comprehension

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Abstract

This study of 4- to 6-year-olds had two aims. First to determine how lower-level comprehension skills (receptive vocabulary and grammar) and verbal memory support early higher-level comprehension skills (inference and literal story comprehension). Second to establish the predictive power of these skills on subsequent reading comprehension. Eighty-two children completed assessments of nonverbal ability, receptive vocabulary and grammar, verbal short-term memory, and inferential and literal comprehension of a picture book narrative. Vocabulary was a unique predictor of concurrent narrative comprehension. Longitudinally, inference skills, literal comprehension and grammar made independent contributions to reading comprehension one year later. The influence of vocabulary on reading comprehension was mediated through both inference and literal comprehension. The results show that inference skills are critical to the construction of text representations in the earliest stages of reading comprehension development.

Keywords: inference, narrative comprehension, vocabulary, grammar, reading comprehension, memory

The relations between lower- and higher-level comprehension skills and their role in prediction of early reading comprehension

Understanding what we read is an essential aspect of good literacy and, consequently, a strong influence on an individual's wider educational and economic success. Across a range of countries, school literacy skills predict subsequent vocational and academic training (PISA, 2001) and, as advanced countries see a decrease in low-skill jobs, an individual's literacy skills are more important than ever for employment choice and success (Darcovich et al., 1997). A clear understanding of the skills that support the development of reading comprehension will enable targeted interventions to prevent literacy failure and benefit both the individual and society, more widely. This paper provides information essential to achieve this aim, by identifying the skills that support early discourse-level comprehension and the importance of higher-level discourse skills in the earliest stages of reading comprehension development.

Successful reading comprehension results in a coherent memory-based representation of the state of affairs described in the text, often referred to as a situation model (Kintsch, 1998). According to multicomponent views of reading comprehension, readers aged 7 to 12 years draw on language knowledge and cognitive processes at the word-, sentence-, and discourse-level when constructing this representation (Oakhill & Cain, 2012; Perfetti, Landi, & Oakhill, 2005; Vellutino, Tunmer, Jaccard, & Chen, 2007). They decode words, retrieve their meanings, combine these into larger units such as clauses and sentences guided by syntactic knowledge, and integrate information across different parts of the text, often drawing on background knowledge to infer information that the author has left implicit. Thus,

comprehension of explicitly stated information (literal comprehension) and implicitly stated information (inference) are involved in the construction of the situation model. With the exception of decoding, the same language knowledge and skills support comprehension of both written and spoken discourse (Kendeou, Savage, & van den Broek, 2009). Therefore, it is not surprising to find that listening comprehension predicts concurrent reading comprehension in children aged 7 to 12 years (Vellutino et al., 2007). In this paper we focus on comprehension of narrative in 4- to 6-year-olds with two specific aims: to determine the contributions made by vocabulary, grammar, and verbal memory to inference and literal comprehension, both key components of discourse comprehension, and also to determine if inference and literal comprehension predict unique variance in subsequent reading comprehension of narrative, in addition to the contributions made by vocabulary, grammar, and verbal memory.

Comprehension of discourse goes beyond word and sentence level understanding and thus draws on both lower-level and higher-level skills (Hogan, Bridges, Justice, & Cain, 2011). Lower-level language comprehension skills such as vocabulary and grammar, which are also referred to as foundational language skills (Lepola, Lynch, Laakkonen, Silven, & Niemi, 2012), are essential for the comprehension and production of more complex discourse. Some argue that only the lower-level skills of vocabulary and grammar are critical for comprehension and the source of difficulty for reading comprehension impairment (Hulme & Snowling, 2011). However, others propose that higher-level skills, such as inference and literal comprehension (of information presented in the text), are independently important in the prediction of listening and reading comprehension in addition to vocabulary and grammar (Florit, Roch, & Levorato, 2011; Lepola et al., 2012; Oakhill & Cain, 2012).

Inference involves going beyond the explicit details in a text and includes integrating information between different sentences and also between information in the text and general knowledge to fill in details that are only implicit. Inference is considered essential for good narrative comprehension because it is necessary for the construction of an integrated and coherent model of the text's meaning (Graesser, Singer, & Trabasso, 1994). Comprehension of the information stated explicitly in the text is also essential to the construction of the situation model (Kintsch & Kintsch, 2005) because, without a secure representation of facts, the model would be incomplete and inferences could not be drawn. Indeed, studies of children with poor reading comprehension have found poor recall of literal information, as well as poor inference making (Cain, Oakhill, Barnes, & Bryant, 2001; Catts, Adlof, & Weismer, 2006), highlighting the important role of memory for explicitly stated detail. Because young children often fail to make sufficient inferences, some have argued that young children's situation models may primarily comprise explicitly stated information (Florit et al., 2011), perhaps as a precursor stage to representations that additionally encode inferences.

Drawing on the multicomponent view of reading comprehension, several recent studies of 4- to 6-year-olds have sought to disentangle the contributions made by lower-level skills and higher-level skills in the prediction of narrative comprehension (Florit et al., 2011; Kendeou, Bohn-Gettler, White, & van den Broek, 2008; Lepola et al., 2012; Tompkins, Guo, & Justice, 2013). A converging finding is that young children's inference skills are predictive of broader measures of concurrent narrative comprehension in addition to vocabulary knowledge in 4- to 6-year-olds (Florit et al., 2011; Kendeou et al., 2008; Tompkins et al., 2013). Longitudinally, Lepola and colleagues found that inference making skills at 4 and 5 years contributed

directly to listening comprehension at 6 (Lepola et al., 2012). They also found that for older children inference, but not vocabulary or grammar, was a unique contributor to listening comprehension taking into account the autoregressive effect of early listening comprehension skill. Thus, convergent with research with older children on the components of reading comprehension (Cain, Oakhill, & Bryant, 2004; Oakhill & Cain, 2012), these studies suggest that inference skills may make an independent prediction to reading comprehension, over and above lower-level skills. Few studies have explored the role of literal comprehension but those that have show that it makes an important contribution to text comprehension in general (Florit et al., 2011).

The key role identified for inference does not rule out the importance of other aspects of language, such as vocabulary and grammar, in the determination of discourse comprehension. Knowledge of the meanings of the words in a text is obviously important for good comprehension of that specific text. Thus, it is not surprising to find that vocabulary predicts unique variance in story comprehension in 4- to 6-year-olds concurrently (Florit et al., 2011; Tompkins et al., 2013) and also longitudinally (Lepola et al., 2012; Muter, Hulme, Snowling, & Stevenson, 2004).

The use of grammatical knowledge to work out the structure and meanings of individual sentences is also necessary for discourse comprehension, but research to date on its contribution to early reading comprehension is mixed. Grammar predicts reading comprehension longitudinally alongside vocabulary between 5 to 6 years (Muter et al., 2004), but not in older readers between 7 to 11 years when in competition with vocabulary and higher-level skills (Oakhill & Cain, 2012). When examining grammar's concurrent contribution to 5-year-olds' listening comprehension, the data are also contradictory: in some studies grammar does not predict variance in listening comprehension when in competition with vocabulary and

measures of verbal working memory (Florit, Roch, & Levorato, 2013), whilst in others studies it does (Potocki, Ecalle, & Magnan, 2013). These discrepant findings may have arisen because the measures of grammar in these studies tapped different things: understanding of different syntactic structures was assessed directly in the studies that did not find a unique relationship (Florit et al., 2013; Oakhill & Cain, 2012), whereas reflection on the sense or well-formedness of sentences, which is a metalinguistic skill, was the measure used in the studies that did find a unique relationship (Muter et al., 2004; Potocki et al., 2013). Together, these studies do not speak directly to the role of grammar knowledge in the longitudinal prediction of reading comprehension in our target age group.

Our review of the literature indicates that a range of language skills determines discourse comprehension and that inference is important from an early age. However, inference itself draws on other language skills and, as noted above, some have argued that word and sentence comprehension underlie performance on inference, at least in the case of children who have poor reading comprehension (Hulme & Snowling, 2011). If that is the case, we would expect vocabulary and/or grammar to predict and support young children's inference making and, further, should find that inference itself does not predict unique variance in reading comprehension when in competition with these other predictors.

An analysis of the reasons for a relation between vocabulary, grammar, and inference making indicates how these lower-level skills might underpin inference making skill. Vocabulary may enable inference because many inferences are constructed by mapping the meanings of related words such as synonyms and category exemplars (Cain & Oakhill, in press; Cain & Oakhill, 1999; Perfetti, Yang, & Schmalhofer, 2008). However, work to date with preschoolers suggests that

inference is supported but not fully determined by vocabulary (Florit et al., 2011; Lepola et al., 2012), indicating that vocabulary alone is not sufficient to ensure inference making. Similarly, preschoolers' ability to answer questions about explicit stated content in the text (literal comprehension) is not fully determined by vocabulary knowledge (Florit et al., 2011).

Grammar may also be predictive of inference making because knowledge of grammar includes cohesive devices, which are important for integrating the meanings of sentences (Cain & Nash, 2011). Cohesive devices often invite the reader to generate an inference necessary to support integration, consider: *'Jack lent Bill his umbrella, because he wanted to keep dry'* and *'Ruby left the party early after Stephen arrived.'* Consequently, there are good theoretical reasons to expect knowledge of grammar to support inference making.

The direct relation between grammar and inference has not been investigated empirically to date, although there are some data that speak to this for older children. Oakhill and Cain (2012) found that knowledge of grammar correlated with inference making in 8- to 11-year-olds; however, they did not test whether grammar predicted unique variance in addition to vocabulary. Thus, we do not know if grammar and vocabulary in combination can explain young children's performance on an inference task. Research with younger children also does not clarify the unique role of grammar knowledge in the prediction of inference either: Lepola et al. (2012) found that a measure of sentence repetition did not contribute significantly to inference skills one year later. However, the measure in Lepola et al.'s (2012) study tapped both knowledge of sentence structure and different aspects of the working memory system including both storage and the episodic buffer (Alloway, Gathercole, Willis, &

Adams, 2004). For these reasons, the current research base does not permit a clear interpretation of the role of grammar in the prediction of inference.

As noted above, verbal working memory is critical to many aspects of language and there is a wealth of research demonstrating its role in vocabulary learning, sentence processing, and inference, as well as reading comprehension in general (Cain, Oakhill, & Lemmon, 2004; Daneman & Merikle, 1996; Hannon & Frias, 2012; Montgomery & Evans, 2009). Some argue that verbal working memory provides essential cognitive support for language processes and may be particularly important for discourse comprehension because it enables the language user to represent written and spoken information accurately so that it can be integrated into their meaning based model of the text (Carretti, Borella, Cornoldi, & de Beni, 2009). According to that view, verbal working memory would predict variance in reading comprehension in addition to language skills. Others propose that language skills such as vocabulary influence verbal working memory (Hulme & Snowling, 2011; Nation, Adams, Bowyer-Crane, & Snowling, 1999) and that these lower-level language skills explain the relation between memory and higher-level language skills.

Certainly, verbal short-term memory is related to young children's vocabulary (Florit et al., 2011; Willis & Gathercole, 2001) as well as their grammar and sentence comprehension (Cain, 2007; Montgomery, 1995). Research with skilled adult comprehenders demonstrates an independence between verbal working memory and vocabulary in the prediction of inference (Calvo, 2005). Research with children has not tested this relationship directly, but broadly supports a view of partial independence: the relationship between 9-year-olds' inference ability and verbal working memory is not fully mediated by vocabulary (Chrysochoou, Bablekou, & Tsigilis, 2011). Of interest, is whether or not verbal working memory explains unique

variance in inference and reading comprehension in younger children, or whether any such relation is due to the mediating effect of lower-level language skills. As noted by Lynch and colleagues, comprehension in younger children might be reduced to understanding at the word level, although they did not find support for this position (Lynch et al., 2008). It is essential to understand the unique as well as the combined (or related) effects of different aspects of language on reading comprehension development in order to specify an accurate framework for instruction and intervention (C. Adams, Clarke, & Haynes, 2009).

Measures of verbal working memory tasks that tap both storage and processing of information, for example reading and listening span tasks, are related to reading comprehension in children and adults (Daneman & Merikle, 1996) and also inference making (Cain, Oakhill, & Bryant, 2004; Chrysochoou et al., 2011). The use of verbal working memory tasks that tap both storage and processing is considered unsuitable for children under 6 years of age because this age group finds the tasks difficult and, as a result, scores are restricted (A. M. Adams, Bourke, & Willis, 1999; Daneman & Blennerhassett, 1984; Gathercole, Pickering, Ambridge, & Wearing, 2004). The correlations between language comprehension and measures of short-term verbal memory tasks, such as word and digit span, and verbal working memory tasks are comparable in young children (A. M. Adams et al., 1999). For that reason, the use of short-term verbal span tasks is considered a suitable proxy for verbal working memory for children in this age range (Florit et al., 2011). When sensitive independent measures of verbal memory are used, they share small to moderate correlations with literal comprehension and inferential processing in 4- to 6-year-olds (Florit et al., 2011; Hannon & Frias, 2012).

The Current Study

The present study had two central aims, which served to extend our understanding of the relations amongst lower- and higher-level language skills and memory in 4- to 6-year-olds and their relation to reading comprehension, one year later. Our first aim was to examine the relationship between the lower-level (or foundational) skills of vocabulary and grammar knowledge, verbal memory, and the higher-level (discourse) skills of inference making and literal comprehension in 4- to 6-year-olds. In line with previous research, we predicted that vocabulary would be specifically related to inference but that other skills would also play a role. We hypothesised that grammar should make a unique contribution to inference skill, based on our analysis of cohesive ties and their role in inference and integration. The previous research literature also supported a prediction that verbal memory would predict concurrent inference skill that was at least partially independent of vocabulary skill (Cain, Oakhill, & Bryant, 2004; Calvo, 2005; Chrysochoou et al., 2011). There has been no work directly contrasting the prediction of literal and inferential comprehension in this age group by lower-level language and verbal memory measures. However, zero-order correlations between memory, vocabulary, literal, and inferential comprehension indicate that verbal memory and vocabulary are strong predictors of literal comprehension in this age group (Florit et al., 2011; Hannon & Frias, 2012), in contrast to the pattern of prediction for older children (Oakhill, Cain, & Bryant, 2003).

Our second question was whether inference and literal comprehension predicted reading comprehension one year later independently of vocabulary, grammar, and verbal memory. Previous research has demonstrated that vocabulary and grammar (Muter et al., 2004) and also vocabulary and inferential skills (Kendeou, van den Broek, White, & Lynch, 2009) are predictive of subsequent reading

comprehension between the ages of 4 and 6 years. To date we lack knowledge of the relations between these oral language skills and later reading comprehension because there are no published studies that have included measures of word-, sentence-, and discourse-level comprehension. If inference is determined by vocabulary, grammar, and/or verbal memory, the relation between inference and subsequent reading comprehension should be indirect and mediated by these skills. In contrast, if inference makes a direct contribution to reading comprehension as is found for older children (Oakhill & Cain, 2012), inference should predict unique variance in reading comprehension in addition to that predicted by lower-level skills. Similar predictions follow for the relation between literal comprehension and reading comprehension.

To study narrative of young children we use a picture-book format. There are strong relations between both children and adults' comprehension of narrative presented in different formats: understanding of narratives presented as a sequence of static pictures or an animated cartoon are predictive of understanding of verbal narratives that are either read aloud to the comprehender or read by the comprehender (Gernsbacher, Varner, & Faust, 1990; Kendeou, van den Broek, et al., 2009). This research supports Paris and Paris' (2003) recommendation that comprehension of narrative presented in a familiar picture book format can be used as a proxy for discourse-level reading comprehension in non-independent readers, as we do in our study. Through our research aims, this study makes a valuable and unique contribution to our knowledge of the skills that underpin inference making and literal comprehension of narrative and how language skills that tap comprehension at the word-, sentence-, and discourse-level contribute to the early stages of reading comprehension development.

Method

Participants

Eighty-two 4- to 6-year-olds from three UK primary schools participated in this study. To capture general developmental trends and to align our study with recent relevant research (Florit et al., 2011; Hannon & Frias, 2012), a two-year age range of children at the early stages of literacy instruction was included. All spoke English as their first language. There were 40 children from Reception classes (23 boys and 17 girls, $M = 62$ months, $SD = 3.50$) and 42 children from Year One classes (21 boys and 21 girls, $M = 74$ months, $SD = 3.58$). Reception is the first year of primary school in the UK and all children participate in a daily literacy hour, from the start of school in accordance with the UK national curriculum. One year later, 69 of the original sample were retested: 34 children from the original Reception class (19 boys and 15 girls) and 35 from the original Year One class (19 boys and 16 girls). Children with special educational needs were excluded from the study. Signed parental consent was obtained for all participants. Information about parental education was obtained for 72% of the sample and indicated a mixed sample: 35% had finished their education with GCSEs (General Certificate of Secondary Education) examinations that are usually taken at 16 years; nearly 24% had completed A-levels (Advanced level examinations) or an equivalent qualification (usually taken at 18 years); and 41% of the sample had completed a University degree.

Design and Materials

At each assessment point, children completed a range of cognitive and language assessments. The standardised measures completed by children were administered according to the manual guidelines. For these measures, standardised scores are reported to relate performance related to age norms, but raw scores were

used in the analysis. For the experimental narrative measures, raw scores are reported throughout.

General cognitive ability. The Matrix Reasoning subtest from the Wechsler Preschool and Primary Scale of Intelligence – Third Edition (Wechsler, 2003) was administered to evaluate (non-verbal) cognitive ability. In this task, the child is presented with a series of four pictures with a blank space and is asked to choose, from a range of pictures the one that fits best (reported Cronbach's α = .90).

Verbal memory. Verbal short-term memory was assessed using the Digit Span task from the British Abilities Scale (Elliott, Smith, & McCulloch, 1996). Children are required to repeat a series of digits after listening to them read out by the experimenter. The quantity of digits to be remembered increases progressively from two, until a ceiling level of performance is reached (when the five trials in a given block are not correctly recalled). The maximum score for this test is 34.

Receptive vocabulary. Receptive vocabulary knowledge was assessed using the British Picture Vocabulary Scale – II (Dunn, Dunn, Whetton, & Burley, 1997). In this task, the child is shown sets of four pictures. For each set, the tester speaks a word and the child's task is to point to the picture that depicts the spoken word (Median Cronbach's α = .93).

Knowledge of grammar. The Test for Reception of Grammar – Second Edition (Bishop, 2003) was used to assess knowledge of different grammatical structures. In this task, the child is shown sets of four pictures. For each set, the tester speaks a sentence and the child's task is to point to the picture that depicts the sentence (split-half reliability calculated for blocks for each set of grammatical contrasts, r = .88).

Experimental assessment of inference making and literal comprehension.

We used the wordless picture book 'Frog on his own' (Mayer, 1973) to assess inference making and literal comprehension. The book comprises a series of pictures depicting a clear plot line about a child who goes to the park with his animal friends: a dog, a frog, and a turtle. The frog escapes and has some adventures in the park before he is finally saved from a dangerous situation by the boy, resulting in a happy ending. For this study, the original version of the book was edited to create a shorter version of 18 pictures by deleting those that were not necessary to understand the main problem and its resolution. The final version was scanned, printed, laminated, and assembled into a book format, including the cover page with title.

Our task was a modified version of the 'Narrative Comprehension' task used by Paris and Paris (2003) and had three parts: picture viewing, narrative production, and narrative comprehension. The latter two parts of the task were audio recorded and transcribed in CHAT format (MacWhinney, 2000) for later analysis. First the child viewed the pictures to familiarise him/herself with the book and its plot and was then asked to tell the story, using the pictures in the book as a prompt. Data from these components are not reported here because they are not related to our research aims.

After the storytelling, each child was asked nine questions to tap his/her understanding of the components that were assessed in the storytelling. The questions were modified from those used by Paris and Paris (2003), as follows. Five questions tapped implicit information and required an inference to answer correctly. We refer to these as questions to assess inference making. Four of these questions tapped the same categories of information used in Paris and Paris (2003): dialogue, feelings, prediction, and theme. We replaced the causal inference question with one on thoughts, because this was particularly relevant to our choice of picture book. Four

(rather than the five used by Paris and Paris, 2003) questions tapped explicit information: characters, setting, problem identification, and resolution. We refer to these as questions to assess literal comprehension. We did not include a question about the initiating event because, during pilot work, it became evident that this question ('What happens at this point in the story? Why is this an important part of the story?') resulted in poor engagement with the rest of the task, because children were unclear how to answer it.

The questions were asked in a fixed order to follow the story line and each was scored on a 0 to 2 point scale in line with previous research using this paradigm (Paris & Paris, 2003; Petersen, Gillam, & Gillam, 2008). One point was awarded for the identification of a particular element in the story (e.g. feelings) and an additional point for the elaboration of this element (e.g. the cause of the observed feeling). The questions and response scoring are provided in Appendix A. Two independent coders scored 20% of the responses. Inter-rater agreement each question was good, all Cohen's kappa over .72. All discrepancies were resolved through discussion. Two summed scores were produced: one for the five inference making questions (maximum score = 10) and one for the four literal comprehension questions (maximum score = 8).

Standardised measure reading comprehension. One year after the initial assessments children were revisited in their schools and completed an assessment of reading comprehension: the Neale Analysis of Reading Ability - II (Neale, 1997). This is an individually administered test standardized to provide reading-age equivalent scores from 5 to 13 years. Children read texts increasing in length and after each text, a set of questions to tap memory for literal details and inferable information is asked. Word reading errors are corrected up to a prescribed limit: testing is

discontinued when this is reached. The reading comprehension score is based on the number of comprehension questions answered correctly. Children completed Form 1 for which reading comprehension reliability is .91 for this age range.

Procedure

At Time One, each child was assessed in three separate sessions, each lasting no longer than 15 minutes. In the first, receptive vocabulary and verbal short-term memory were assessed. In the second, the narrative task was administered. In the final session, general cognitive ability and knowledge of grammar were tested. At Time Two, the reading comprehension task was administered to children individually in a session lasting no longer than 20 minutes.

Results

The results are presented in three sections. First, we describe the descriptive statistics and the interrelations between our variables; second we present the analyses relating to the first set of aims concerning the prediction of inference making and literal comprehension; finally, we present the analyses relating to our second aim to determine the unique contributions of our measures to the prediction of reading comprehension one year later. Some children did not complete every task at each time point because consent forms were not returned, or because they moved away from the area. The data presented here include only those children for whom full data are available: Time 1, N = 82; Time 2, N = 69. No significant differences in ability scores were found between children continuing at Time 2 and those who did not participate in the second part of the study (all ps > .05). In addition, the pattern of differences between Time 1 and Time 2 scores was the same when using the full sample at Time 1 or the reduced sample (test of correlations revealed no significant differences in strength of associations for the two samples).

Descriptive Statistics and Interrelations between Variables

The means, standard deviations, and range of scores for general ability, verbal short-term memory, and vocabulary, grammar, inference making and literal comprehension at Time 1, and reading comprehension at Time 2, are shown in Table 1. The scores indicate that general cognitive ability and receptive vocabulary were all within the normal range at each time point. In contrast, children obtained low scores on the assessment of knowledge of grammar. Examination of the data distributions for the Time 1 measures revealed that skewness and kurtosis were all within acceptable limits (all below 1.10) and that none of the measures suffered from floor or ceiling effects. Examination of the reading comprehension scores as Time Two indicated two clear outliers. These datapoints were treated in the manner recommended by Tabachnik and Fiddell (2007) whereby outlier data points are changed to the next highest/lowest (non-outlier) number. After this treatment, the skewness and kurtosis were within acceptable limits (all below 1.00). All analyses were conducted using the raw data.

INSERT TABLE ONE AROUND HERE

The concurrent correlations are shown in Table 2, and also the correlations between the Time 1 measures of Time 2 reading ability. As expected, chronological age was significantly correlated to all measures, in particular the correlations with nonverbal IQ, grammar, and inference were moderate, and the correlation with vocabulary was large. The language measures were significantly correlated with each other. Of note, the correlation between vocabulary and inference was large, but the correlation between grammar and inference was small. Further, inference and literal comprehension shared only a moderate correlation. Verbal short-term memory was significantly and moderately correlated with vocabulary and inference making, but

not the other language measures. All Time 1 measures, except memory, were

correlated with reading comprehension one year later and the strengths of the

relationships were typically moderate to large.

<div align="center">INSERT TABLE TWO AROUND HERE</div>

Do Vocabulary, Grammar and Verbal Short-term Memory Uniquely Predict

Inference Making and Literal Comprehension?

The central aim of this set of analyses was to determine the extent to which a

discourse-level skill, comprehension of narrative, is underpinned by lower-level

language skills and verbal short-term memory. Two sets of fixed-order hierarchical

multiple regression analyses were performed. In one set, inference making was the

criterion; in the other, literal comprehension was the criterion. In each analysis, age

and nonverbal IQ were entered in the first step as control variables. The variables that

might contribute to performance on inference making and literal comprehension of

narrative (vocabulary, grammar, memory) were then entered in step 2 in separate

analyses to determine if they each made a significant unique contribution to the

prediction of each outcome.

<div align="center">INSERT TABLE THREE AROUND HERE</div>

After controlling for age and general cognitive ability, only vocabulary

predicted significant additional variance in both inference making ($\Delta R^2 = .08$, $p < .05$)

and literal comprehension ($\Delta R^2 = .10$, $p < .01$). These findings extend the work of

Tompkins et al., (2013) and Lepola et al (2012) demonstrating that vocabulary

knowledge is important not only for inferential comprehension, but also for literal

comprehension of narrative, after controlling for age and also nonverbal IQ.

What Predicts Later Reading Comprehension?

The analyses reported in this section address our second aim: do either inference or literal comprehension predict unique variance in later reading comprehension over and above vocabulary, grammar and verbal short-term memory? To address this question we conducted a series of analyses. First, given our limited sample size for the number of potential predictors, we examined the contribution of each variable that was significantly correlated with reading comprehension (vocabulary, grammar, verbal short-term memory, inference, literal comprehension) after controlling for age and nonverbal IQ for the purpose of saving degrees of freedom in the final models. The results are shown in Table 4 and demonstrate that all of these measures with the exception of verbal short-term memory predicted unique variance in reading comprehension outcomes. In our final models, we therefore excluded only verbal short-term memory, which was not significantly correlated with reading comprehension.

To align our findings with our first set of analyses and to maintain a reasonable number of participants per predictor variable, we then determined the prediction of reading comprehension by inferential comprehension and literal comprehension separately, after controlling for age and nonverbal IQ in the first step, and then vocabulary and grammar entered in the second step. These analyses are reported in Table 5. As is clear, both inference and literal comprehension predicted unique variance in reading comprehension when entered last. Examination of the final standardised Beta coefficients showed that grammar, but not vocabulary, also made a significant contribution to the prediction of reading comprehension in each analysis.

We followed up these findings to determine if the relation between vocabulary and reading comprehension was mediated by the influence of vocabulary on either grammar and literal comprehension, or grammar and inference, in order to align with

the previously tested models. The new models are summarised in Figure 1. We followed the recommendations of Preacher and Hayes (Preacher & Hayes, 2008) and conducted bootstrapped tests for the indirect (mediated) effect, based on 1000 bootstrap samples. In these two analyses, the contributions made by age and nonverbal IQ were controlled. A point estimate for the indirect effect (of vocabulary via either grammar and literal comprehension or grammar and inference) was considered statistically significant if zero was not included in the 99% bias-corrected confidence intervals. In the analysis that included grammar and inference we found that inference was a significant mediator of the relationship between vocabulary and reading comprehension (PE= .064, BC 99 %CI of .006 to .183). The same was not true for grammar (PE= .037, BC 99 %CI of -.017 to .120). In the analysis that included grammar and literal comprehension we found the same pattern: literal comprehension was a significant mediator of the relationship between vocabulary and reading comprehension (PE= .100, BC 99 %CI of .023 to .231) but not grammar (PE= .031, BC 99 %CI of -.006 to .109).

<div align="center">FIGURE ONE AROUND HERE</div>

<div align="center">**Discussion**</div>

The current study makes two new contributions to our understanding of early language and literacy development. First, vocabulary is shown to be a more critical factor in the prediction of 4- to 6-year-olds' inference skill than either grammar or short-term verbal memory. Second, knowledge of grammar, inference making and literal comprehension each exert independent influences on reading comprehension over time, whilst vocabulary does not when considered in conjunction with these variables. We discuss these key findings first and how they inform theoretical models of language and literacy development, and then consider the implications for practice.

The relations between lower- and higher-level language skills in young children

Inferences as well as understanding of explicitly stated information are fundamental to the construction of an adequate representation of a narrative and good story comprehension (Graesser et al., 1994). We found that during the earliest stages of literacy development, both were predicted by vocabulary and that grammar and verbal short-term memory did not explain additional unique variance. These findings identify a unique and critical role for vocabulary in early inference making and literal comprehension: after the variance accounted for by age and nonverbal ability, vocabulary was the sole predictor of variance in each.

We propose the following reasons for the relation between these two skills. First, a test of vocabulary indicates how well word meanings are established and knowledge is interconnected. To understand even explicitly stated information, the core vocabulary must be understood. Second, as a story unfolds an individual with richer vocabulary knowledge will activate a greater range of associated concepts and be better prepared to make inferences to support comprehension than someone with poorer knowledge (Elbro & Buch-Iverson, 2013; Perfetti, 2007; Perfetti & Stafura, 2014). Third, vocabulary and inference share a bi-directional relation: word knowledge supports inference making and, critically, inference from context is a driver of vocabulary learning from written and spoken texts (Cain, Oakhill, & Lemmon, 2004; Elley, 1989). For these reasons, there is a strong relation between vocabulary and inference, as demonstrated in our analyses of the prediction of inference.

When readers construct an accurate and coherent situation model they draw on their comprehension of explicit details in a text, in addition to inference making. Our study is unique by including questions to tap literal comprehension of the story and

exploring the factors that underpin this ability. As with inferences, vocabulary was found to be an independent predictor of literal comprehension, providing further evidence of the key role of vocabulary in early discourse comprehension. We note that inference, vocabulary, grammar and verbal short-term memory were all correlated, and that literal comprehension was also significantly related to grammar as well as vocabulary. We do not argue that grammar and verbal short-term memory (or verbal working memory) are not important in supporting the discourse-level skills that are involved in the construction of a situation model; rather that vocabulary may share a particularly strong relation with discourse-level skills for the reasons explained earlier. These findings demonstrate the specificity of early vocabulary on discourse comprehension in young children by demonstrating that vocabulary knowledge is important not only for inferential comprehension, but also for literal comprehension of narrative, after controlling for age and nonverbal IQ. In this way, these findings extend the work of Tompkins et al., (2013) and Lepola et al. (2012).

The Role of Lower- and Higher-Level Language Skills in the Prediction of Early Reading Comprehension

An important advance in our understanding of the development of early reading skills is our finding that inference making and literal comprehension, both higher-level language skills, predicted reading comprehension one year later. Our pattern of data demonstrating that higher-level language skills explain unique variance in reading comprehension outcomes in beginner readers is in line with studies of reading comprehension outcomes in older age groups, which demonstrate that higher-level language skills are important for skilled text comprehension as well as lower-level language comprehension skills such as vocabulary (Kendeou et al., 2009; Oakhill & Cain, 2012). Thus, together these studies strongly suggest that, across a

wide age range, knowledge additional to vocabulary and grammar is required to comprehend and produce a story and to understand the structure and relations between story events, for example the ability to integrate the information, to make inferences between the events, and understand character's goals and motivations (van den Broek, 1997).

In addition to inference making and literal comprehension, we found that grammar made a unique contribution to later reading comprehension, which is in line with previous longitudinal research (Muter et al., 2004) albeit using a different measure. Clearly, grammar is important to understand individual sentences and, for that reason, it has perhaps been described as a lower-level or foundational skill (e.g. Lepola et al., 2012). Surprisingly, we did not find a unique role of grammar in the prediction of literal or inferential comprehension, over and above vocabulary. One possibility is that the different response formats of the grammar and discourse comprehension measures – picture selection vs response to open-ended questions – was the reason for this lack of relation. However, the vocabulary assessment also required picture selection and vocabulary was related uniquely to literal comprehension and inference making, so this does not appear to be an adequate explanation. The relation of grammar to different discourse skills may depend on the content of the assessment, which is suggested by the mixed findings on its relation to reading comprehension (e.g., compare Muter et al., 2004 and Oakhill & Cain, 2012). Knowledge of grammar includes linguistic markers that mark the coherence relations between events, such as causal and temporal connectives (Cain & Nash, 2011; Sanders & Maat, 2006), which aid the integration of information between clauses and sentences. For this reason, we propose that future work on discourse comprehension should include measures of grammar that tap these specific markers of meaning to

understand better the specific role of grammar in young readers' construction of situation models from connected prose.

One finding that was unexpected given previous research (Muter et al., 2004) was that vocabulary did not independently predict subsequent reading comprehension when in competition with grammar, inference making, and/or literal comprehension. However, our findings are in line with other empirical work that shows that higher-level language skills are important to an individual's language proficiency and may make an additional and unique contribution to reading and listening comprehension outcomes (Kendeou, Savage, et al., 2009). For example, vocabulary has been found to be related to narrative measures for 4-year-olds but not 6-year-olds (Lynch et al., 2008). Indeed, such findings are consonant with the analysis reported by National Early Literacy Panel (NELP, 2008), which found that the best prediction of early reading comprehension is evident when vocabulary, grammar, and discourse-level measures are all included as predictors, and that measures of receptive vocabulary, such as the one used in the current study, were amongst the weakest predictors (Hogan, Cain, & Bridges, 2012).

Why then was vocabulary a significant predictor of concurrent inference making and literal comprehension but not later reading comprehension, given the strong theoretical and empirical relation between narrative comprehension and reading comprehension? We think that there are three possible reasons for this finding. First, the initial stories on the reading comprehension measure used for this age group contain very easy vocabulary. Thus, children may well have had sufficient knowledge of all of the key words. In such circumstances, the skills that contribute to the integration of ideas in a text tapped by our measures of grammar and inference will have greater predictive power, as we found here. Vocabulary may be a more

powerful predictor of reading comprehension for stories that contain less frequent critical words. Second, research on the assessment of reading has shown that oral language skills (such as receptive vocabulary and grammar) differ in the strength of their association with individual reading comprehension assessments (Cutting & Scarborough, 2006). Although other research has shown that the assessment of reading comprehension used here is predicted longitudinally by vocabulary and grammar (Muter et al., 2004; Nation, Cocksey, Taylor, & Bishop, 2010), it remains a possibility that our findings are (in part) due to our use of a single specific measure of reading comprehension and that different relations would be found if an alternative assessment had been used.

Third, vocabulary was related to reading comprehension indirectly through its relation with both inference making and literal comprehension. This finding leads to two critical conclusions. The first is that vocabulary clearly does enable higher-level skills, as proposed by Hulme and Snowling (2011) amongst others. However, our mediation analyses show that inference and literal comprehension are not fully determined by a lower-level skill such as vocabulary and make a unique contribution to reading comprehension.

A surprising but important finding was that verbal short-term memory was not a particularly strong predictor of performance on our measures of narrative comprehension or grammar, nor of later reading comprehension. We note that this was not due to task sensitivity: there was no evidence of floor or ceiling effects. Research with older children finds a stronger relation between verbal short-term memory tasks and reading comprehension when the materials used in the memory task have semantic content, rather than the number stimuli used in our task (Nation et al., 1999). This finding is supported by a study of 5- to 10-year-olds, which found that

the effects of verbal short-term and working memory on young children's inference making were largely mediated by vocabulary (Chrysochoou et al., 2011).

An additional implication of our findings is how they speak to the theoretical construct of language and the skills that contribute to reading comprehension. Our early language measures all included pictures of the stimuli and, therefore, drew on the storage and processing of pictorial information. Despite this similarity in format, we found that our measures of vocabulary, grammar, and discourse comprehension were only moderately correlated concurrently, which suggests that these do tap different levels of language knowledge and processing. Moreover, our analyses reveal the importance of discourse-level skills to the prediction of reading comprehension, a pattern that accords with research with young readers (Oakhill & Cain, 2012; Vellutino et al., 2007). Our study demonstrates even in the early phases of reading development, higher-level language skills make a unique contribution to the determination of reading comprehension, in addition to the contribution made by lower-level skills (see also Florit et al., 2011, who found a similar pattern for the concurrent prediction of listening comprehension).

As our discussion makes clear there are several limitations to this study. There is a clear need to replicate this study with a larger sample size and multiple measures of each construct to test more robustly the relations between young children's lower- and higher-level language skills and their reading comprehension. Such work could usefully contrast measures of verbal memory that differently tap semantic processes (e.g., digit vs word span) to confirm our explanation for the absence of strong memory effects in this study. In addition, the use of verbal memory measures that tap both storage and processing should be included should they prove sensitive to variability in this age group, as has been suggested by recent research (Florit et al.,

2013). Another limitation is that we were not able to examine if different skills predicted word reading and reading comprehension outcomes, as proposed in the simple view of reading (Gough, Hoover, & Peterson, 1996). Kendeou and colleagues have demonstrated that different skill sets underpin performance on word reading and reading comprehension tasks (Kendeou, van den Broek, et al., 2009; Tilstra, McMaster, van den Broek, Kendeou, & Rapp, 2009) and precursors to those skills (Kendeou, Savage, et al., 2009). Our study supports this viewpoint that language comprehension skills, including narrative comprehension, are important to reading comprehension. However, our findings are limited in how they support the simple view of reading because we did not include measures of the precursors of word reading.

In addition to the theoretical contributions outlined above, our evidence for the importance of higher-level language skills for comprehension suggests several practical implications. First, we need to assess language beyond the comprehension of single words to capture critical predictors of discourse-level comprehension. Second, our work supports the call for a stronger focus on higher-level skills such as inference in the preschool and elementary classroom (Hogan et al., 2011; Rapp, van den Broek, McMaster, Panayiota, & Espin, 2007). We do not propose that this should be at the neglect of teaching vocabulary and grammatical skills, because words and sentences are clearly the building blocks of narrative. Indeed, our study points to the importance of early vocabulary to support inference and early grammatical knowledge to aid the integration essential to constructing coherent representations of text. However, our findings strongly suggest that a broad range of language skills need to be included in the early literacy curriculum.

In summary, it is important to understand what underpins the development of a child's ability to construct coherent and integrated sequences of events in a story because of the relation between early narrative skills and later reading comprehension. Our findings suggest that a variety of language skills are important in this process: vocabulary plays a crucial role in early inference making and literal comprehension and, critically, inferential skills are important from the outset of reading comprehension development.

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Table 1

Means, Standard Deviations, and Range of Scores for General Ability, and Language Skills

	M	SD	Range	Standardised score
Variable	(raw scores)			
Nonverbal IQ	15.09	5.19	2-26	10.17
Verbal short-term memory	17.14	4.49	5-28	110.07
Vocabulary	58.38	12.19	33-89	100.87
Grammar	6.00	3.87	0-18	85.18
Inference making (max = 10)	5.43	2.25	1-10	-
Literal comprehension (max = 8)	4.59	2.02	0-8	-
Reading comprehension	8.19	6.92	0-37	95.48

Table 2

Interrelations Between Measures at Time 1 and Longitudinal Correlations with Reading Comprehension

Variable	1	2	3	4	5	6	Reading comprehension
1. Chronological age	--						.39**
2. Nonverbal IQ	.30**	--					.40***
3. Verbal short-term Memory	.28**	.12	--				.22
4. Vocabulary	.58***	.33**	.40***	--			.47***
5. Grammar	.39**	.58***	.18	.43***	--		.53***
6. Inference making	.47**	.19	.31*	.50***	.26*	--	.48***
7. Literal comprehension	.23*	.28*	.10	.41***	.31*	.44***	.51**

Note. N=82 for correlations between variables 1-7 and N=69 for correlations with reading comprehension. *$p < .05$; **$p < .01$; ***$p < .001$.