Title

The Role of Linguistic Information in Learning Abstract Words:Evidence from Children with Specific Language Impairment (SLI)

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The Role of Linguistic Information in Learning Abstract Words: Evidence from Children with Specific Language Impairment (SLI)

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Abstract

Accounts of abstract word learning suggest that learning these words relies primarily on access to linguistic cues, such as the statistical co-occurrence of words with similar semantic properties. Thus, children with language impairment (LI), who by definition have impoverished access to linguistic context, should have disproportionate impairments in abstract word knowledge. Here, we compared verbal definitions and lexical decisions to both abstract and concrete words of children with LI (ages 8 to 13) and both age-matched and vocabulary-matched typically developing (TD) peers. Relative to age-matched peers, children with LI had significant deficits in both tasks. Crucially, however, there was not greater impairment of abstract words. We conclude that that linguistic knowledge is not *a sine qua non* to learning abstract words and concepts and other mechanisms, which are not specifically impaired in LI, are at play.

Keywords: abstract concepts; semantic representation; distributional semantics; lexical decision; specific language impairment (SLI); vocabulary development.

Introduction

Children learn thousands of words quickly and efficiently, often without any formal training, and even in impoverished environments. Learning words is hard because even when the referent is present in the physical environment, rarely it is isolated in the visual scene (Medina, Snedeker, Trueswell & Gleitman, 2011). To make the situation worse, referents are not always present in the physical environment, either because they are spatially and/or temporally displaced (e.g., talk about past or future events), or because they are abstract and have no tangible referent. Most theories of vocabulary acquisition focus on the mechanisms by which words referring to concrete concepts (i.e. objects, actions and other events that can be experienced with our senses and through our own actions) can be learnt; it is less clear how a child learns abstract concepts, which are not perceivable by the senses.

It has been argued that children learn the meaning of concrete words such as "cat" or "run" by observing the statistical contingencies between the words and the objects,

people and actions occurring in the physical environment (e.g., Yu and Smith, 2007). In addition, such contingencies could be enhanced by the use of social communicative cues, such as eye-gaze, or pointing, through which caregiver directs attention to the correct referent (Baldwin, 1991) or by infants actively isolating intended referents from the visual background by picking them up (Morse, Benitez, Belpaeme, Cangelosi & Smith, 2015).

Word meanings, however, can also be learnt from the linguistic context in which the words occur (Firth, 1957). Recent work has demonstrated how models of semantic memory, based on co-occurrences of words in text (also called *Distributional Semantic Models*), can predict a variety of semantic effects in adults and children (e.g., Andrews, Vigliocco & Vinson, 2009; Bruni, Tran & Baroni, 2014; Landauer & Dumais, 1997; Griffiths, Steyvers & Tenenbaum, 2007). This strategy could complement, at least for concrete words, other social-cognitive strategies. For abstract words, distributional information may provide a powerful, if not the most important, mechanism for learning (e.g., Andrews et al., 2009; Johns & Jones, 2012).

In line with distributional semantic models, abstract words are acquired late in development (Kousta, Vigliocco, Vinson, Andrews & Del Campo, 2011; Ponari, Norbury & Vigliocco, in press; Schwanenflugel, 1991). Early studies of children's language production (Brown, 1957, reported in Schwanenflugel, 1991) suggested that 75% of the words most frequently produced by school-aged children (6-12 years of age) were concrete; in contrast, only 28% of the words used most commonly by adults were concrete. Schwanenflugel (1991) further reported that, while 6-year-old children have already mastered the majority of concrete words most frequently used by adults, it is not until adolescence that children have mastered the majority of abstract words used by adults. These facts align well with the idea that a sufficient amount of linguistic input is necessary to extract meaning for abstract words.

Thus, if the ability to learn meaning from co-occurrences in the input is critical for learning abstract concepts and words, abstract words should be especially challenging for

children with developmental language impairments (LI). Language impairment is a neurodevelopmental disorder affecting approximately 7.5% of children at school entry (Norbury et al. 2016, Tomblin et al. 1997). Children with LI have language abilities significantly below expectations for age in the absence of obvious social, sensory or neurodevelopmental explanations. Children with LI typically present with severe deficits in morphosyntax and other aspects of grammar (Rice, 2013), accompanied by vocabulary that is reduced in both breadth and depth relative to typically-developing peers (McGregor, Oleson, Bahnsen & Duff, 2013). Unfortunately there is a dearth of empirical investigation into the acquisition of abstract words by children with LI.

Here, we investigate implicit and explicit knowledge of abstract and concrete words in children with Language Impairment (LI). Target words were selected at different age of acquisition bands and controlled for variables that are known to affect adult processing, including frequency, number of letters and valence. Lexical decision was used to test implicit knowledge, while verbal definitions were used to test explicit knowledge.

Methods

Participants

Eighteen children with an existing diagnosis of Language Impairment (LI; 14 males; mean age = 10.03, SD = 1.76) were recruited from schools in Southeast England. Children in the TD groups were selected from a pool of 73 children who completed both tasks and were matched to the children with LI on age and gender (TD$_{age}$; n = 18, 14 males; mean age = 10.34, SD = 1.44) or by raw scores on the *British Picture Vocabulary Scale* (BPVS; Dunn, Dunn, Whetton, & Burley, 1997) (TD$_{vocab}$; n = 18, 14 males; mean age = 8.16, SD = 2.12). TD children were recruited from local schools and did not have any reported special educational needs, or history of language delay. Children's non-verbal cognitive abilities were assessed using the Matrix Reasoning test of the Wechsler Abbreviated Scale of Intelligence (WASI, Wechsler, 1999). LI children were also administered the Recall Sentences subtest of the Clinical Evaluation of Language Fundamentals: Core Language Scales (CELF; Semel, Wiig, & Secord, 2006), see Table 1. The same children participated in both tasks.

Materials

Thirty-six abstract and 36 concrete words were selected from a pool of 3,505 words for which normative data on a range of lexical variables could be obtained. These variables included: Age of Acquisition (AoA; Kuperman, Stadthagen-Gonzalez & Brysbaert, 2012), concreteness, familiarity (Coltheart, 1981), valence (Warriner, Kuperman & Brysbaert, 2013), and frequency (Balota et al., 2007). AoA ratings were used to ensure the items selected were appropriate for our participants' age: words were divided into Age of Acquisition bands (1: words acquired at 4-5

years of age; 2: words acquired at 6-7 years; 3: words acquired at 8-9 years; 4: words acquired at 10-11 years). Within each AoA band, triplets of negative (valence ratings < 4.0), positive (valence ratings > 6.0) and neutral (valence ratings of 4.5-5.5) words matched on length (number of letters), concreteness, log frequency and familiarity were created. Triplets of abstract words were then paired to concrete triplets matching for average length, frequency and familiarity. Among these 72 words, 24 (12 abstract and 12 concrete) were shared between the two tasks; 24 (12 abstract and 12 concrete) were used for the definitions task only, and the remaining 24 were used for the lexical decision task only. Additionally, for the lexical decision task, forty-eight pronounceable non-words were created by changing one phoneme from 48 words matched to the experimental words on length, AoA, valence and concreteness. All words and non-words were recorded by a native English speaker using Audacity v. 1.2.2.

Table 1. *Demographic characteristics of LI, TD$_{age}$ and TD$_{vocab}$ children and performance at the background tests, means (standard deviations).*

		Age-matched			Vocabulary-matched	
	LI	TD$_{age}$	t-test	p	TD$_{vocab}$	t-test	p
Age	10.40 (1.83)	10.33 (1.44)	0.127	.899	8.16 (2.12)	3.383	.002
Matrix reasoning	40.33 (10.67)	49.22 (9.37)	2.656	.012	51.41 (8.31)	3.413	.002
BPVS	108.72 (25.03)	129.66 (14.74)	3.059	.004	109 (24.25)	0.034	.973
CELF recall sentence	4.83 (4.23)	NA	-	-	NA	-	-

Procedure

All children were tested in a quiet room in their school and received stickers for participation. Stimuli were presented acoustically using E-Prime version 2.0 software (Psychology Software Tools, Pittsburgh, PA) running on a Dell Latitude E6320 laptop with a touchscreen display. Children were presented with short computer games in which they were asked to help a cartoon alien learn English. The Definitions task was always presented before the Lexical Decision task, in a single session.

Definitions. After wearing the headset (which included a microphone), children were presented with a practice trial (the concrete noun: "rose") before the experiment. They were encouraged to provide an accurate and comprehensive definition, including as much information as they could on the meaning of each word. Each trial included the presentation of the alien in the center of the computer screen, along with the auditory presentation of an English word. Children's responses were audio-recorded using E-Prime and then scored off-line. The 48 words were presented in four blocks of 12-items arranged in AoA blocks (block 1: words acquired at 4-5; block 2: words acquired at 6-7; block 3: words acquired at 8-9; block 4: words acquired at 10-11); words within each block were presented in random order. The task ended when the subject was unable

to define three words within a single AoA block or responded to all 48 words.

Scoring of definitions We used a 0 to 4 scale. Four points were awarded if an answer showed complete semantic understanding of the word; 3 points if an answer showed a good understanding of the word (e.g., one or more features of the concept); 2 points if the answer provided correct but generic information that doesn't help to identify the element in an unequivocal way (e.g., giraffe = animal; anger = a feeling); 1 point if the answer was not wrong, but poor in content (e.g., evening = is when we dine); 0 point if the answer was wrong; no answer was given; or the concept was repeated (e.g. Photo = to take a photo). Scoring was performed by two independent researchers who were blind to the identity or diagnosis of the children. Interclass correlation coefficient (ICC) was computed to determine the level of agreement between the two scorers, yielding a high degree of reliability, ICC = .86 (95% CI: .845 - .879), $p <$ .001. A third independent researcher moderated instances in which the scores differed by more than 1 point (12.6% of all definitions), and the instances in which only one scorer awarded a score of 0; all other scores were averaged.

Lexical decision. Children were presented with six practice trials (three non-words and three words that were not used in the experiment). In each trial, a cartoon alien was presented in the middle of the screen for 1000ms, followed by the auditory presentation of either a real English word or a non-word. Immediately after the offset of the word (average stimulus duration = 830 ms), two touch screen buttons appeared at the bottom left (a red thumbs-down icon) or the bottom right (a green thumbs-up icon) of the screen (see Figure 1).
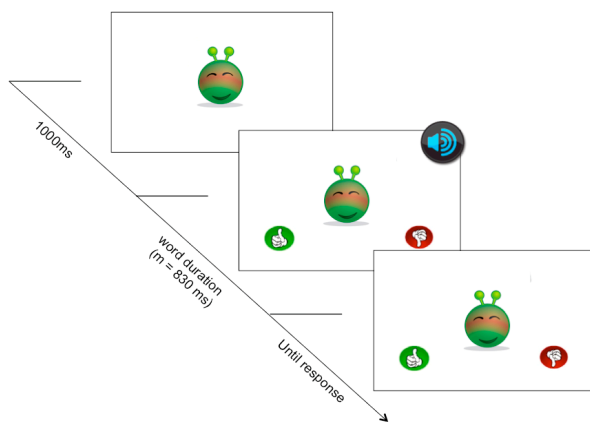

Figure 1 – Lexical decision task. Trial timeline.

Children were instructed to press the green button when they heard a word they knew, or the red button if they heard a "funny, made-up" word. After the six practice items, participants completed all 96 items (24 abstract and 24 concrete words, plus 48 non-words) presented in a randomised order.

Data analysis Separate mixed-design ANOVAs with concreteness (abstract, concrete) as within-subject factor and group (LI, TD) as between-subject factor were used to analyse average rating (in the definition task) and accuracy (in the lexical decision task), for both age-matched groups and vocabulary-matched groups.

We further assessed the individual performance of children with LI on abstract and concrete words against the difference in those conditions exhibited by matched TD controls, using the Revised Standardized Difference Test (RSDT) (Crawford and Garthwaite, 2005a, 2005b). This test was developed in neuropsychology research to test for dissociation between patient performance on two or more tasks. Here, the two concreteness sets (abstract, concrete) are treated as the two different 'tasks', and the difference in performance between them is evaluated against TD averages. The RSDT controls for Type I error rates when there are correlations between the tasks under study; we entered simple correlations between abstract and concrete raw scores from the TD groups.

Results

Definitions

Only 13.4% of our TD children could provide any definition for words of AoA block 4 (words acquired at 10-11); therefore, we excluded block 4 from further analyses, thus reducing the total number of items to 36 words (18 abstract and 18 concrete).

LI vs TD$_{age}$. Average accuracy ratings for definitions provided by children with LI and matched TD$_{age}$ children for concrete and abstract words are shown on Figure 2 (top-left). A mixed ANOVA yielded a significant main effect of concreteness, F(1, 34) = 9.277, p = .004, η_p^2 = .214, with concrete words (1.31) attracting more complete and accurate definitions than abstract words (0.80). The main effect of group was also significant, F(1, 34) = 20.314, p < .001, η_p^2 = .374; definitions provided by children with LI (0.80) were rated as significantly poorer in quality than those given by their age-matched TD peers (1.63). However, the group × concreteness interaction was not significant (p = .427), indicating that poor quality definitions were provided for both abstract and concrete words by children with LI.

LI vs TD$_{vocab}$. One TD$_{vocab}$ child did not complete the task and his definitions were excluded along with data from the matched child with LI. Average ratings of definitions provided by LI and matched TD$_{vocab}$ children (n = 17 per group) for concrete and abstract words are shown on Figure 2 (top-right). Analyses demonstrate a significant main effect of concreteness, F(1, 32) = 21.687, p < .001, η_p^2 = .404, with concrete words (1.31) eliciting more accurate and detailed definitions than abstract words (0.86). Importantly, the group × concreteness interaction were not significant (all p > .170).

Individual LIs vs control group comparisons. Individual performance of LI children against matched TD$_{age}$ and TD$_{vocab}$ groups is shown on Figure 2 (bottom). For all children with the LI group, the abstract vs concrete

comparison was not significantly different from the pattern shown by both age-matched and vocabulary-matched peers.
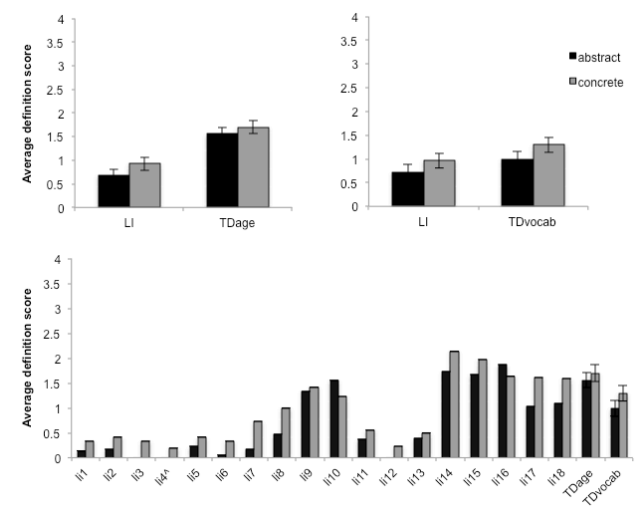

Figure 2 - <u>Top</u>: Average score (on a 0-4 scale) of definitions to abstract and concrete words, comparing performance of LI with TD_{age} (N = 18; left), and with TD_{vocab} (N = 17; right) children. Error bars indicate standard error of the mean. <u>Bottom</u>: Proportion of errors for individual LI children and the TD_{age} and TD_{vocab} groups in defining abstract and concrete words. ^Child LI4 was not included in the comparison with the TD_{vocab} group. Error bars for the TD groups data indicate standard error of the mean.

Lexical decision. In order to ensure children attention and compliance to task instructions, the examiner controlled stimulus presentation and did not ask the children to respond quickly, but rather as accurately as possible. Reaction times are therefore not reliable and our analyses are limited to accuracy (proportion of correct responses).
Pre-processing. We checked the children's overall performance with words and non-words to determine whether some of the children showed a bias toward either answering "word" or "non-word". We computed the response bias (or *criterion, c*), calculated by multiplying the sum of the normalised *hit* rate (correctly identifying a word) and the normalised *false alarm* rate (incorrectly claiming that a non-word was a word) by -0.5 (e.g., Fox, 2004). The average criterion bias was -0.002 (SD = 0.33) for TD children, and -0.02 (SD = 0.50) for children with LI. Children who showed a criterion bias higher than 1.5 standard deviations above their group mean (indicating a strong bias toward "non-word" responses) or lower than 1.5 standard deviations below their group mean (indicating a strong bias toward "word" responses) were excluded from further analyses. Using these criteria, 3 children were excluded from the LI group (LI9: *c* = -0.97; LI12: *c* = -0.74; LI17: *c* = -0.97); to maintain the matching between the LI and TD groups, we also excluded the corresponding TD children.

LI_{age} vs TD_{age}. Proportion of correct responses of the 14 LI and matched TD_{age} children for concrete and abstract words is shown on Figure 3 (top-left). There was no main effect of concreteness, $F(1, 26) = 1.203$, $p = .283$; but the main effect of group was significant, F(1, 26) = 7.971, p = .009, $\eta_p^2 = .235$, indicating that TD_{age} children (.85) were more accurate overall than children with LI_{age} (.72). Crucially, the group × concreteness interaction was not significant.
LI_{vocab} vs TD_{vocab}. Two TD_{vocab} children did not complete the task; therefore they were excluded along with their matched LI partner. This left 12 children per group for the LI – TD_{vocab} comparison. The proportion of correct responses of LI and TD_{vocab} children for concrete and abstract words is shown on Figure 2 (top-right). In this analysis, there were no significant main effects of concreteness, $F(1, 22) = 1.234$, $p = .279$, or valence, $F(2, 44) = .376$, $p = .689$. Crucially, the main effect of group and the group × concreteness interaction were also not significant (all p > .330).
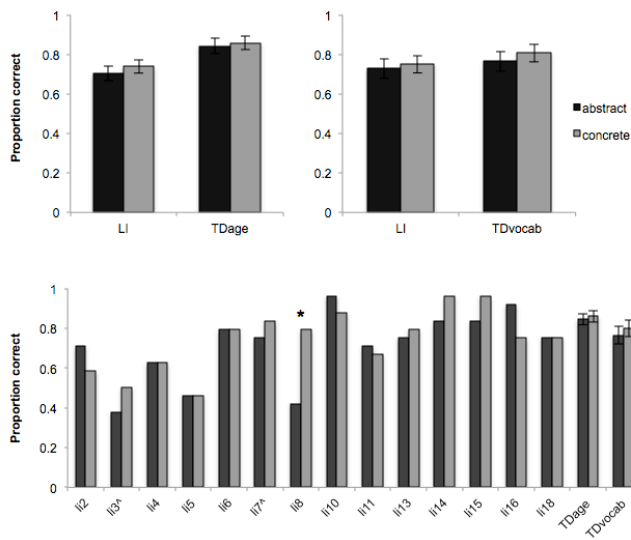

Figure 3 – <u>Top</u>: Proportion of correct responses to abstract and concrete words, comparing performance of LI with TD_{age} (N = 14; left), and LI with TD_{vocab} (N = 12; right) children. <u>Bottom</u>: Proportion of correct responses of individual LI children and the TD_{age} and TD_{vocab} groups for recognition of abstract and concrete words. Children LI3 and LI7 were not included in the comparison with the TD_{vocab} group. The asterisk indicate one child who showed a greater difference between abstract and concrete words when compared against TD_{age} data (p < 0.05, two-tailed). Error bars indicate standard error of the mean.
Individual LIs *vs* control group comparisons. Individual performance of LI children against matched TD_{age} and TD_{vocab} groups is shown on Figure 3 (bottom). In general, the discrepancy between abstract and concrete words was not significantly different from the discrepancy pattern shown by both age-matched and vocabulary-matched TD children. Only one child with LI (LI8) showed a

significantly larger difference between abstract and concrete words when compared to TD$_{age}$ peers, t(13) = 3.342, p = .005. This difference reflected an advantage for concrete (.79) over abstract (.42) words. In all other children, the abstract vs concrete comparison was not significantly different from either TD$_{age}$ or TD$_{vocab}$ matched controls.

Discussion

We compared performance of children with LI to that of age-matched or vocabulary-matched TD peers on two tasks: the first, a verbal definitions task, provided an explicit measure of children's semantic knowledge of abstract and concrete words. The second, a lexical decision task, did not require linguistic output and served as implicit measure of word processing. Both tasks used concrete and abstract words that were matched on a number of variables known to affect word processing in adults, such as frequency, valence, age of acquisition and length.

In the definition task, we found a significant effect of concreteness, indicating that concrete words were easier to define by both children with LI and their age- and vocabulary-matched peers. This may be because to define abstract words, children need to retrieve other abstract words and these latter may be more difficult (not just because of their abstractness but also because they may be longer, less familiar etc) than the concrete words they need to retrieve for defining the concrete stimuli. Importantly, we found that children with LI were significantly worse than their age-matched peers in defining <u>all</u> words, both concrete and abstract. When compared with younger TD children matched for receptive vocabulary, no difference was found between the two groups. There were no significant interactions between concreteness and group, indicating that even when LI children are worse overall than TD peers in defining words, they do not have disproportionate difficulties defining abstract words. By analysing the performance of individual LI children against the difference between abstract and concrete words shown by the two TD comparison groups, we further demonstrated that this is a finding consistent across the whole sample. No individual child with LI showed a greater impairment defining abstract words relative to concrete words.

In the lexical decision task, there was no significant effect of concreteness, which is consistent with findings in the adult literature that, when all lexical variables that have been shown to favour concrete words (such as length and familiarity) are tightly controlled, the concreteness advantage disappears (see Kousta et al., 2011). Critically, we again found that children with LI were significantly less accurate overall in making decisions about words relative to their age-matched TD peers, but there was no interaction between group and concreteness. In other words, even on this implicit task, children with LI were not disproportionately impaired in their processing of abstract words compared to concrete words. The case-series analyses comparing individual LI children with their age- or vocabulary-matched controls once again confirmed that

even at an individual level, children with LI responded to abstract and concrete words in a similar manner to that of TD children, for all but one child (LI8).

These findings challenge any theory that posits linguistic competence as a necessary prerequisite for acquiring abstract words. Children with LI do not have the same vocabulary competence as typically developing children (McGregor et al., 2013), moreover it has been shown that they do not take advantage of correlational information to the same extent as their typically developing peers (Evans, Saffran & Robe-Torres, 2009). For all these reasons, learning abstract words should present an almost insurmountable challenge for them. However, children with LI in the current study, despite their language limitations, did not show any evidence of disproportionate deficits in abstract word knowledge.

Distributional Semantics models offer a powerful mechanistic account of how word meanings can be acquired from language. On the basis of the linguistic contexts in which a word is used, children could make inferences about word meaning (e.g., Landauer & Dumais, 1997, Griffiths et al., 2007; Andrews, Vinson & Vigliocco, 2009). Such a mechanism would be at play for both concrete and abstract words, although it could play a greater role for abstract words. Our results indicate that whereas these mechanisms can be at play, there is no evidence for them to have a different role for concrete and abstract words. Our results may also be considered to be problematic (especially if replicated with argument bearing verbs) for the "syntactic bootstrapping hypothesis (e.g., Gleitman et al., 2005), according to which phrasal and syntactic information is used to constrain possible word meanings. Gleitman et al. (2005) specifically discuss how this information may be especially important in learning verbs (which are more abstract than nouns). Under the plausible assumption that our children with LI have a history of problems in processing sentence-level linguistic structure, our results suggest that such a strategy may not be the only manner in which children learn abstract vocabulary.

Thus, other mechanisms are also at play. Ponari, Norbury, and Vigliocco (in press) presented initial evidence that learning abstract words could be based on multiple strategies and, at least in the earlier stages of acquisition, take advantage of the strong association between abstractness and emotional valence (Kousta et al., 2011). Emotional valence could support the establishment of the distinction between concrete and abstract domains of knowledge because, while concrete words would refer to observable entities and actions that we can experience with our senses and act upon, abstract words would refer to internal states of self and others that trigger embodied emotional reactions and experiences. These emotional reactions could come about from interactions with caregivers in which children associate words heard with emotions expressed by the caregivers or by the child themselves. Such a view posits that communicative social interaction would play a central role in language acquisition,

along the lines proposed by recent social-cognitive theories of lexical development (e.g., Tomasello, 2000). To this end, it is important to note that children with LI do not show evidence of fundamental socio-cognitive deficits. It is interesting to note that emotion, however, does not seem to have a privileged role abstract vocabulary after the age of 9 (cf. Ponari et al., 2017). It is likely that by this age, strategies grounded in basic socio-cognitive processes (e.g., ability to make inferences on others intentions) or emotional experience become insufficient to differentiate among the meanings of an increasingly larger number of abstract words in the child's vocabulary and language-based strategies may become more important.

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