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Speed of word recognition and vocabulary knowledge in infancy predict cognitive and language outcomes in later childhood

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Abstract

The nature of predictive relations between early language and later cognitive function is a fundamental question in research on human cognition. In a longitudinal study assessing speed of language processing in infancy, Fernald, Perfors and Marchman (2006) found that reaction time at 25 months was strongly related to lexical and grammatical development over the second year. In this follow-up study, children originally tested as infants were assessed at 8 years on standardized tests of language, cognition, and working memory. Speed of spoken word recognition and vocabulary size at 25 months each accounted for unique variance in linguistic and cognitive skills at 8 years, effects that were attributable to strong relations between both infancy measures and working memory. These findings suggest that processing speed and early language skills are fundamental to intellectual functioning, and that language development is guided by learning and representational principles shared across cognitive and linguistic domains.

Introduction

The question of predictive relations between early and later mental capacities is central to understanding cognitive development. Although initial studies of infant cognition found little continuity from infancy to childhood (Bayley, 1949), there is now substantial evidence that individual differences in cognitive skills in infancy as well as in early language growth are associated with later outcomes. Longitudinal studies show that information-processing abilities in the first year predict performance on verbal and nonverbal cognitive tasks in childhood (Bornstein, Hahn, Bell, Haynes, Slater, Golding, Wolke & ALSPAC Study Team, 2006; Colombo, 2004). In addition, vocabulary size in infancy is strongly related to early lexical and grammatical development (Bates, Bretherton & Snyder, 1988) and to linguistic and cognitive abilities at 4 years of age (Feldman, Dale, Campbell, Colborn, Jurs-Lasky, Rockette & Paradise, 2005).

Although research on the predictive validity of information-processing abilities in infancy has focused primarily on efficiency in interpreting visual stimuli, there is growing interest in how infants' skill in interpreting auditory stimuli may also relate to later development. Recent studies show how individual differences in rapid auditory processing, phonological knowledge, and segmentation abilities in the first year relate to lexical development in the second and third years (Benasich & Tallal, 2002; Tsao, Liu & Kuhl, 2004; Kuhl, Conboy, Padden, Nelson & Pruitt, 2005; Newman, Bernstein Ratner, Jusczyk, Jusczyk & Dow, 2006). These studies have all used tasks that assess perception of speech sounds that are not yet meaningful to preverbal infants. In a recent longitudinal study, Fernald, Perfors and Marchman (2006) used an online procedure that requires infants to listen for meaning in spoken language, finding robust

relations between real-time measures of comprehension and linguistic development from 12 to 25 months. However, no previous studies have examined the long-term predictive validity of early efficiency in spoken language understanding, nor the relation of early vocabulary development to outcomes beyond the preschool period. Here we extend the Fernald *et al.* longitudinal study by assessing the same children observed as infants on standardized tests at 8 years of age, asking whether speed of word recognition and vocabulary size in infancy are associated with linguistic and cognitive abilities later in childhood.

Speed of information processing is core to theoretical conceptualizations of continuity in cognitive functioning (Colombo, 2004; Jensen, 1993; Kail, 1991). In research with infants, various measures of processing efficiency have been derived from visual expectation, habituation, and recognition memory paradigms (Haith, Wentworth & Canfield, 1993; Rose & Feldman, 1997). For example, infants who habituate more rapidly are viewed as more adept at attending to, encoding, and retrieving visual information, skills fundamental to cognitive growth, and individual differences in such early processing measures are associated with verbal and nonverbal intelligence in later childhood (Bornstein *et al.*, 2006; McCall & Carriger, 1993). In older children and adults, processing speed is considered fundamental to general intellectual functioning, including the ability to abstract and integrate information efficiently during problem-solving and reasoning tasks (Kail & Salthouse, 1994). Moreover, processing speed is often compromised in children with language and cognitive impairments (Miller, Leonard, Kail, Zhang, Tomblin & Francis, 2006).

The ability to rapidly process speech sounds is central to understanding language in real time. Adults interpret words incrementally as the speech signal unfolds, and lexical access is facilitated by efficient processing of word-initial information (Marslen-Wilson & Zwitserlood, 1989). Since listeners must continuously integrate linguistic and non-linguistic information from moment to moment, rapid processing also facilitates the tracking of multiple lexical-semantic and morphosyntactic cues that constrain the interpretation of the discourse, and the integration of such probabilistic cues with the visual context (e.g. Altmann & Kamide, 1999).

Constraints on spoken language understanding have also been framed in terms of working memory capacity. In adults, accurate interpretation of complex sentences is compromised when working memory is taxed, for example when listeners must divide processing resources across tasks (Just & Carpenter, 1992). In preschool and school-age children, individual differences in phonological working memory correlate with vocabulary development (Gathercole & Baddeley, 1993), and processing limitations related to working memory are central to theories of language disorder (e.g. Montgomery, 2002). Although there is debate regarding whether working memory operates on linguistic and non-linguistic information in similar ways (MacDonald & Christiansen, 2002), language understanding depends crucially on having sufficient resources to manage multiple sources of information over brief periods of time. At the same time, variation in the effective use of limited working memory resources is substantially attributable to individual differences in processing speed, and developmental increases in children's working memory capacity are causally linked to age-related increases in speed of information processing (Kail & Salthouse, 1994; Fry & Hale, 1996). Research has only just begun to examine efficiency of spoken language understanding in the early phases of language learning, and little is known regarding links between early language processing and later working memory skills.

In the first study to explore the early development of speed of language processing using real-time measures, Fernald, Pinto, Swingley, Weinberg and McRoberts (1998) tested infants in an eye-tracking task that monitors the time course of comprehension. In this 'looking-while-listening' task, infants look at pictures of familiar objects while hearing speech naming one of the pictures, and video-records of gaze patterns are coded frame-by-frame. Fernald *et al.* found

that the mean latency to shift from the distracter to the named target picture decreased 300 ms on average between 15 and 24 months. Other studies using online measures reveal that 2-year-olds, like adults, interpret speech incrementally based on probabilistic cues (Fernald, Swingley & Pinto, 2001; Swingley, Pinto & Fernald, 1999), exploit morphosyntactic regularities (Lew-Williams & Fernald, 2007; Zangl & Fernald, 2007), and are increasingly able to integrate semantic and grammatical information with the visual context (Thorpe & Fernald, 2006). The first longitudinal study using this method found that infants' efficiency at integrating probabilistic linguistic and non-linguistic information in interpreting speech was correlated with lexical and grammatical outcomes (Fernald *et al.*, 2006). Specifically, those 25-month-olds who were faster to orient to the appropriate referent had more accelerated vocabulary growth and more complex multi-word combinations. One explanation for these relations is that infants who are faster to encode the auditory signal in relation to the visual scene also have more robust lexical representations that can be reliably accessed during language production. Greater speed in word recognition during early language learning may facilitate children's success both in inducing the meanings of novel words from linguistic and non-linguistic context, and also in tracking morphosyntactic regularities that are critical for lexical and grammatical growth. In this research, we investigate these hypothesized links between early efficiency in online comprehension and outcomes later in childhood, with particular attention to working memory.

A parallel goal is to explore the long-term predictive validity of measures of early lexical development based on the MacArthur-Bates Communicative Development Inventory (CDI), a parent-report instrument used widely for research and clinical purposes (Fenson, Marchman, Thal, Dale, Reznick & Bates, 2006). Although studies have shown that CDI measures of expressive vocabulary in infancy predict language outcomes through age 4 (Feldman *et al.*, 2005; Bornstein & Haynes, 1998), none have examined such continuities beyond the preschool years. Vocabulary knowledge is assumed to be a core aspect of general intelligence, and performance on standardized vocabulary tests is highly correlated with performance on more general tests of IQ (Dunn & Dunn, 1997). There is also considerable evidence for associations between children's vocabulary development and phonological working memory (Gathercole & Baddeley, 1993). Finally, recent theoretical accounts propose domain-general continuity between the representations and learning mechanisms driving early lexical growth and children's language and cognitive outcomes more generally (Bates & Goodman, 1999). Here we also examine links between vocabulary size at 2 years and expressive language, IQ, and working memory measures later in childhood.

In this longitudinal follow-up study, we contacted families of children who had participated as infants in the Fernald *et al.* (2006) study for whom we had both online measures of processing speed and CDI measures of vocabulary size at 25 months. At the age of 8 years, these children were assessed on standardized tests of cognition and language. The long-term predictive validity of speed of word recognition and expressive vocabulary at 25 months to full-scale IQ and expressive language at 8 years was assessed using multiple regression. Predicted links between the infancy measures and later performance on tasks of working memory were of particular interest.

Method

Participants

Participants were 28 children ($M = 8$ yrs, 5 mos; $SD = 1.6$ mos) from primarily Caucasian, college-educated families who had participated in the Fernald *et al.* (2006) longitudinal study. Thirty of the original 63 families who met selection criteria still lived in the area, and all but two agreed to take part in the follow-up study. None of the 25-month measures for this sub-

sample differed significantly from those of children for whom follow-up data were unavailable (all $p > .25$).

Speed of processing at 25 months

Stimuli—As described by Fernald *et al.* (2006), speech stimuli consisted of 24 prerecorded sentences with familiar object names as sentence-final target words (e.g. *Where's the doggie?*). Visual stimuli were pairs of digitized photographs of objects corresponding to target words, matched in size and brightness. Each object served equally often as target and distracter.

Procedures and measures—In the looking-while-listening procedure (see Fernald, Zangl, Portillo & Marchman, 2008), the infant was seated on the parent's lap facing two computer monitors. On each trial, images appeared for 2 s prior to speech onset and 1 s after speech offset, with target/distracter status and presentation side counterbalanced within participants. Eye movements were video-recorded and coded later by trained observers blind to trial type. For each 33-ms frame, coders indicated whether the child was looking left, right, between, or away from both pictures. Trials were designated as distracter-initial or target-initial depending on which picture the child was fixating at target-noun onset. Reaction time (RT) was the mean latency to shift from the distracter to the target picture on distracter-initial trials, based on all shifts initiated within 300–1800 ms from target-word onset. For some analyses, children were grouped as fast vs. slow responders based on a median split of mean RTs (765 ms).

Vocabulary at 25 months

Vocabulary was the number of words reported on the MacArthur-Bates Communicative Development Inventory (CDI): Words & Sentences. For some analyses, children were grouped as high vs. low vocabulary size (median split: 400 words).

IQ and language at 8 years

A trained examiner administered the Clinical Evaluation of Language Fundamentals – 4th edn. (CELF-4; Semel, Wiig & Secord, 2003). Standard scores were derived for the Expressive Language Index (ELI), including expressive vocabulary, formulating sentences, recalling sentences, and word structure. Standard scores on the Mental Processing Index (MPI) from the Kaufman Assessment Battery for Children, 2nd edn. (KABC-II; Kaufman & Kaufman, 2004) provided a general index of IQ, including spatial reasoning, pattern matching, learning, and problem solving. Working memory was assessed using the sequential processing sub-scale of the KABC-II: (1) *Digit Span*: child repeats increasingly longer sequences of single digits; (2) *Word Order*: child nonverbally identifies (i.e. points to) pictures in the same order as the names were read by the experimenter. A second examiner interviewed the parent regarding the child's hearing, vision, speech/articulation, and academic progress.

Results

Infancy and school-age measures

Descriptive statistics for vocabulary and RT at 25 months are shown in Table 1. Mean vocabulary ranged from < 75 words to near ceiling levels, reflecting the broad variability typical of this age. Although the average latency to orient to the correct referent at 25 months was within ca. 800 ms of target-word onset, there was substantial variability in this measure as well, with mean RTs ranging from 573 to 1083 ms. Table 1 also presents scores from standardized assessments of expressive language (CELF-4), IQ (KABC-II: Mental Processing Index), and working memory (KABC-II: Sequential Processing) at 8 years. As a group, performance fell approximately 1 *SD* above the mean for age norms on expressive language and IQ full-scale scores, with only three children scoring below 100. Average performance also fell

approximately +1 *SD* on the working memory composite, with all but one of the children scoring at or above age-based expectations. No child was reported to be below grade level in any academic subject. Expressive language and working memory were strongly intercorrelated, $r(28) = .66, p < .001$.

Predictive relations between infancy measures and school-age outcomes

Table 2 reports bivariate correlations between RT and vocabulary at 25 months and outcomes at 8 years. Table 3 summarizes three multiple regression models evaluating combined and independent effects of the infancy predictors. Looking first at expressive language, RT and vocabulary together accounted for 41% of the variance, with each predictor making significant unique contributions: Vocabulary: $F(1, 25) = 7.3, p < .02$; RT $F(1, 25) = 6.4, p < .02$. For IQ, the infancy measures together accounted for 39% of the variance, with more substantive unique effects for vocabulary, $F(1, 25) = 9.4, p < .005$, than RT, $F(1, 25) = 3.4, p < .08$. Finally, processing speed and vocabulary size at 25 months accounted for 58% of the variance in working memory at 8 years, with both making equally strong unique contributions: Vocabulary: $F(1, 25) = 13.6, p < .001$; RT: $F(1, 25) = 13.4, p < .001$. Thus, when the two infancy measures were taken together, predictive relations were double that of either predictor individually.

To further illustrate these effects, children were classified into four groups according to their mean RT and vocabulary scores in infancy, based on median splits on both measures at 25 months: (a) Low Vocabulary/Slow RT ($n = 9$); (b) Low Vocabulary/Fast RT ($n = 6$); (c) High Vocabulary/Slow RT ($n = 5$); (d) High Vocabulary/Fast RT ($n = 8$). Figure 1 plots mean standard scores on assessments of expressive language, IQ, and working memory at 8 years for the children in these four groups. One-way main effects of group were significant for each measure: Expressive language: $F(3, 24) = 3.7, p < .03, \eta_p^2 = .32$; IQ: $F(3, 24) = 4.9, p < .009, \eta_p^2 = .38$; working memory: $F(3, 24) = 5.0, p < .008, \eta_p^2 = .38$. However, planned contrasts (all $p < .05$) revealed three somewhat different patterns among the infancy and outcome measures: Children who were in the High Vocabulary/Fast RT group as infants had significantly higher expressive language scores at 8 years as compared to children in all other groups, consistent with a model in which early processing speed and vocabulary work together to impact later outcomes. Children who were in the Low Vocabulary/Slow RT group as infants were at greatest risk for poor performance on both IQ and working memory, scoring significantly below all other groups at 8 years. The intermediate scores in the two mixed groups suggest that faster processing and larger vocabulary in infancy are independently associated with better performance at school-age. For working memory, children who were high on both processing and vocabulary measures as infants were at an even greater advantage in working memory at age 8, as compared to children in other groups.

Given the colinearity between working memory and expressive language, we re-examined predictive relations in a multiple regression model that first controlled for working memory. The unique effects were effectively eliminated when working memory was entered into the models: Vocabulary r^2 -change = 2.9%; RT r^2 -change = 2.3%. Thus, the predictive validity of RT and vocabulary to childhood expressive language is completely attributable to the link between the infancy measures and working memory.

Discussion

This study is the first to show that both speed of spoken language understanding and vocabulary size in 2-year-olds predict cognitive and language skills in later childhood. The infancy measures made sizable contributions to both childhood language and IQ, together accounting for substantial variance in outcomes. However, the strongest relations involved working

memory. Vocabulary and processing speed at 25 months each accounted for significant unique variance in working memory at 8 years, with the infancy variables in combination doubling the predictive power of either one taken individually. These results converge with findings from numerous studies showing that individual differences in infants' efficiency in processing visual information are associated with later intellectual functioning (Rose & Feldman, 1997; Bornstein *et al.*, 2006), and they contribute to an emerging literature exploring how early abilities in auditory processing are also predictive of later language and cognitive development (Kuhl *et al.*, 2005; Newman *et al.*, 2006). Such continuities reveal that infants' skills in attending to, categorizing, and interpreting speech sounds, as well as visual patterns, have long-term consequences for a range of intellectual achievements.

We should note that the current sample is quite homogeneous, consisting of full-term, typically developing children from highly educated families, who almost all performed above average on the school-age assessments. Thus, the current findings may not be representative of those based on samples from more demographically diverse populations. However, recent studies in our laboratory with primarily low-SES Spanish-speaking families find concurrent relations between vocabulary and RT that are similar to those found in the present sample (Hurtado, Marchman & Fernald, 2007). We are currently investigating the prediction that parallel long-term relations will hold for these participants as well. At the same time, many studies of variability in early information-processing abilities have been criticized for including infants with known risk factors, raising concern that developmental continuity was thus overestimated. From that perspective, the strong, direct associations reported here could be viewed as particularly impressive, given the restricted range of this high-functioning sample, and one might expect even stronger predictive validity in a more diverse population with a broader range of test scores.. An important further extension of this work is to assess the sensitivity and specificity of the processing speed measure used here in discriminating children at risk for disorders from typically developing peers, and to evaluate its potential as an early marker for clinical-range deficits.

Our findings also indicate strong relations between vocabulary at 25 months and later language and cognition, extending previous reports of the short-term predictive validity of vocabulary into the school-age years. Parent-report measures are a cost-effective means of assessing children's early language development, and this study provides the first empirical evidence that such measures are meaningfully linked to outcomes in middle childhood. These results suggest that early lexical accomplishments provide a foundation for language and cognitive development more generally, and that the learning principles and representational formats that drive vocabulary growth are linked to those guiding development of a wide array of skills (Bates & Goodman, 1999; Dixon & Marchman, 2007).

Early efficiency in speech processing and vocabulary learning could impact language development in numerous ways. Infants who can more quickly identify the referent of a spoken word have more resources available to process secondary aspects of the referential context that could support more richly instantiated lexical representations. Faster lexical access would also enable the child to attend to subsequent information in the speech stream, facilitating tracking of distributional cues that extend across non-adjacent words and that are crucial for building a working grammar. At the other end of the continuum, children less efficient in processing would require more exposures to the same word to reach the same degree of representational detail as that achieved by a child with more efficient processing, resulting in slower rates of vocabulary growth and weaker systems of relations across phonological and lexical forms (Marchman & Bates, 1994). Such predictions regarding long-term consequences of individual differences in early speech processing efficiency and vocabulary knowledge are strengthened by the continuities observed here.

These results also indicate that relations between infancy measures and later outcomes go beyond language abilities. Rapid and reliable responding in the looking-while-listening task requires many different skills, including encoding and identifying visual images, parsing the acoustic signal, matching the target word to the appropriate referent, and tracking linguistic and non-linguistic information over time in ways not necessarily specific to language. In addition, vocabulary knowledge correlates highly with performance on more general measures of intelligence and is commonly viewed as a proxy for IQ. The current findings support the idea that skills required in learning and processing vocabulary words share important properties with those involved in a wide range of cognitive and linguistic capabilities. Of course, in contrast to the specific relations proposed here, such links might simply reflect a type of broad-based intellectual skill that operates relatively independently across all of these developmental accomplishments. Further studies using complementary methodologies are needed to provide a more comprehensive account of the ways in which speed of language processing and vocabulary are connected to later language and cognitive abilities.

Perhaps the most intriguing finding of this study is that processing speed and vocabulary in infancy were most strongly related to childhood assessments of working memory, and it was these relations that accounted for the predictions to expressive language. Infants' abilities in both learning new words and processing familiar words are related at a more fundamental level to their ability in childhood to store and manipulate information over short periods of time, consistent with well-known links between processing speed, vocabulary size, and performance on working memory tasks in both typical and atypical populations (Gathercole & Baddeley, 1993; Kail & Salthouse, 1994; Montgomery, 2002). It will also be important to replicate these results using tasks that tap into a broader range of verbal and nonverbal working memory skills. Nevertheless, these findings resonate with research documenting that individual differences in working memory correlate strongly with success in language understanding by adults (Just & Carpenter, 1992). We provide here the first evidence that individual differences in working memory abilities in childhood can be traced back to indices of processing speed and vocabulary knowledge in infancy.

Earlier studies have proposed that information processing skills in infancy contribute to a cascade of consequences that build over development (Fry & Hale, 1996; Bornstein *et al.*, 2006). For example, age-related increases in speed of processing lead to greater facility in manipulating information in working memory, which in turn leads to improved intellectual competence. Although both of the infancy measures used here demonstrated direct relations to school-age outcomes, the current findings are also consistent with a model of cascading relations between early efficiency in speech processing speed and increased vocabulary knowledge. Children make impressive gains in the efficiency of spoken language processing over the second and third years of life, just as their vocabulary is undergoing rapid development (Fernald *et al.*, 2006), and working memory scores were highest in children who were both faster in spoken word recognition and had a larger vocabulary at 2 years. These factors may operate in a developmental cascade in which faster speech processing enables more efficient learning of new lexical forms, together facilitating further development in working memory.

These findings clearly show that individual differences in infancy have long-term continuity with later language and cognition. Of course, what accounts for early variability in processing speed remains an intriguing open question. Variation in infant skills could derive from endogenous differences in the neurological mechanisms guiding early perceptual, attentional, or motor development (Colombo, 2004). Individual differences might also result from children's early experiences with language. It is well known that the quantity and quality of child-directed speech are predictive of early vocabulary size (Hart & Risley, 1995). Moreover, a recent observational study revealed that variation in caregiver talk also predicts differences in speech processing efficiency by the child (Hurtado, Marchman & Fernald, under review).

Spanish-learning children with mothers who produced more words and longer utterances at 18 months were relatively faster in word recognition at 24 months, even after controlling for mean RT at 18 months. It could be that children's processing efficiency is facilitated by more dense or more complex talk because those experiences provide extensive practice with interpreting language in challenging contexts. Or perhaps children benefit from richer talk because it provides more robust and reliable links between language and meaningful aspects of the world. These experiences could lead to accelerated growth in vocabulary and grammar as well as to further advances in processing efficiency and working memory capacity.

In sum, this research led to two new discoveries about the continuity of intellectual functioning from infancy to later childhood: First, measures of spoken language processing and vocabulary knowledge at 25 months strongly predicted performance on measures of school-age language and cognitive abilities. And second, the links between these infancy measures and later outcomes involved working memory, which is central to theories of mature competence in language understanding (MacDonald & Christiansen, 2002). While previous studies have shown that individual differences in infants' ability to interpret visual stimuli are related to later cognitive outcomes, this is the first to demonstrate that infants' efficiency in identifying familiar words and finding meaning in spoken language also has long-term predictive validity. These results are consistent with an integrative view in which early processing speed and vocabulary knowledge underlie children's construction of language and relate fundamentally to cognitive development.

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Figure 1.

Mean standard scores on expressive language (CELF-4), IQ (KABC-II: Mental Processing Index) and working memory (KABC-II: Sequential Processing) as a function of vocabulary size and processing speed (RT) at 25 months. Note: Error bars represent *SE* of the mean.

Table 1Descriptive statistics for 25-month and 8-year measures ($n = 28$)

Measure	<i>M</i>	<i>SD</i>	Range
Vocabulary: 25 months ^a	379	181	68–673
RT: 25 months ^b	793	137	573–1083
CELF-4: 8 years ^c			
Expressive Language	115	9	99–130
K-ABC-II: 8 years ^d			
IQ	123	15	86–148
Working Memory	117	13	83–140

Note:^aNumber of words reported as ‘understands and says’ on the CDI: Words & Sentences (max = 680 words).^bMean latency (ms) to shift from the distracter to the target picture on distracter-initial trials.^cStandard scores on the Expressive Language Index (ELI) of the Clinical Evaluation of Language Fundamentals – 4th Edition (CELF-4).^dStandard scores on the Kaufman Assessment Battery for Children – 2nd Edition (KABC-II) based on the Mental Processing Index (MPI) and Sequential Processing sub-scales.

Table 2

Pearson correlation coefficients (r) for vocabulary and RT at 25 months and standardized test performance at 8 years ($n = 28$)

25 months	8 years		
	Expressive language ^a	IQ ^b	Working memory ^c
Vocabulary	.47**	.53**	.59**
RT	-.49**	-.40*	-.59**

Note:

*
 $p < .05$,

**
 $p < .01$.

^a ELI on the Clinical Evaluation of Language Fundamentals – 4th Edn (CELF-4).

^b MPI on the Kaufman Assessment Battery for Children – 2nd Edn (KABC-II).

^c Composite score based on the Sequential Processing sub-scale of the KABC-II.

Table 3

Summary of regression models using vocabulary and RT at 25 months as predictors of standardized test performance at 8 years ($n = 28$)

25-month predictor	8-year outcome					
	Expressive language ^d		IQ ^b		Working memory ^c	
	<i>B</i> (<i>SE</i>)	<i>r</i> ² -ch	<i>B</i> (<i>SE</i>)	<i>r</i> ² -ch	<i>B</i> (<i>SE</i>)	<i>r</i> ² -ch
Constant	127.66 (9.07) **		133.50 (16.47) **		141.10 (12.00) **	
Vocabulary	0.02 (0.01) *	.17 *	0.04 (0.02) **	.23 **	0.04 (0.01) **	.24 **
RT	-0.03 (0.01) *	.16 *	-0.03 (0.02) #	.09 #	-0.05 (0.02) **	.24 **
<i>R</i> ²	.41 **		.39 **		.58 ***	

Note:

$p < .07$,

* $p < .05$,

** $p < .01$.

B = unstandardized regression coefficient; *SE* = standard error; *r*²-ch = unique *r*²-change.

^a ELI on the CELF-4.

^b MPI on the KABC-II.

^c Composite score based on the Sequential Processing sub-scale of the KABC-II.