Learning and Individual Differences 32 (2014) 54–68

Contents lists available at ScienceDirect

Learning and Individual Differences

journal homepage: www.elsevier.com/locate/lindif

Predicting levels of reading and writing achievement in typically developing, english-speaking 2nd and 5th graders ☆,☆☆,★

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ARTICLE INFO

Article history:
Received 25 May 2013
Received in revised form 14 March 2014
Accepted 19 March 2014

Keywords:
Predicting Reading Achievement
Predicting Writing Achievement
Verbal Reasoning
Bidirectional Cognitive–Language Translation
Verbal Working Memory
Language Learning Mechanism

ABSTRACT

Human traits tend to fall along normal distributions. The aim of this research was to evaluate an evidence-based conceptual framework for predicting expected individual differences in reading and writing achievement outcomes for typically developing readers and writers in early and middle childhood from Verbal Reasoning with or without Working Memory Components (phonological, orthographic, and morphological word storage and processing units, phonological and orthographic loops, and rapid switching attention for cross-code integration). Verbal Reasoning (reconceptualized as Bidirectional Cognitive–Linguistic Translation) plus the Working Memory Components (reconceptualized as a language learning system) accounted for more variance than Verbal Reasoning alone, except for handwriting for which Working Memory Components alone were better predictors. Which predictors explained unique variance varied within and across reading (oral real word and pseudoword accuracy and rate, reading comprehension) and writing (handwriting, spelling, composing) skills and grade levels (second and fifth) in this longitudinal study. Educational applications are illustrated and theoretical and practical significance discussed.

1. Introduction

Research across different countries and languages is validating effective ways to teach *reading* (e.g., Adams, Foorman, Lundberg, & Beeler, 2012; Beck & McKeown, 2001; Cain & Oakhill, 2007; Denton, Vaughn, Wexler, Bryan, & Reed, 2012; Stahl & Nagy, 2005), *writing* (e.g., Arfé, Dockrell, & Berninger, in press; Graham, MacArthur, & Fitzgerald, 2007; Limpo & Alves, 2013; Rijlaarsdam, van den Bergh, & Couzijn, 2004; Troia, 2009), and *writing–reading integration* (e.g., Berninger & Abbott, 2010; Graham & Hebert, 2010; Shanahan, 2006), for different age levels, and both typical language learners and those with specific learning disabilities. However, the issue of when a learner has reached an acceptable level of achievement in reading or writing remains unresolved. The challenge in doing so is that variation in levels of reading and writing achievement is normal in typically developing readers and writers as well as those with specific learning disabilities (for review of evidence, see Berninger, 2009). That is why normed tests of specific reading and writing skills have been developed to assess variation in levels of achievement on a specific skill in a specific age group or at a specific grade level. Scores on normed tests fall along a continuous distribution and it is impossible for all students of a certain age or grade to be at exactly the same level of achievement.

Given this normal variation and scores on normed tests falling along a continuous distribution, little is known about how to predict a level of expected achievement in response to instruction (RTI), both for typically developing readers and writers and those with specific learning disabilities. Twin studies across countries have demonstrated that such variations in reading and spelling are influenced by both genetics (inherited traits) and environmental variables (e.g., Byrne et al., 2008; Friend & Olson, 2008; Olson, Byrne, & Samuelson, 2009). One way to sort out the role of genetics in reading and writing achievement is to validate behavioral markers of associated genetic mechanisms. Individually administered measures of such behavioral markers of genetic mechanisms are called phenotypes. Considerable research has validated such phenotypes (e.g., Grigorenko et al., 1997; Plomin, DeFries, McClearn, & McGuffin, 2008; Raskind, Peters, Richards, Eckert, & Berninger, 2012; Schulte-Korne et al., 1998; Wijsman et al., 2000).

Grade-appropriate, evidence-based instructional practices may help students read and write at their current grade level, but may not fully eliminate genetic vulnerability at later grades when curriculum requirements change. Genetic influences on written language learning may still be observed (e.g., Samuelsson et al., 2008); these are thought to (a) be

☆ This research was supported by HD P50HD071764 and HD25858 from the *Eunice Kennedy Shriver* National Institute of Child Health and Human Development (NICHD) at the National Institutes of Health (NIH).

☆☆ This paper is based on a presentation by Berninger, V., Niedo, J., & Abbott, R. (2013, April 20) *Interdisciplinary approach to defining, teaching, and evaluating response to teaching for reading and writing disabilities*. In B. Miller (Organizer). Paper symposium, Improvements in Identification and Classification of Individuals With Reading and Writing Disabilities. Society for Research on Child Development (SRCD). Seattle, WA.

★ **Disclosure**: The third author is the author of PAL receptive coding subtest, one of sixteen test measures used.

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http://dx.doi.org/10.1016/j.lindif.2014.03.013
1041-6080/

heterogeneous for reading and writing skills (Raskind et al., 2012), and (b) affect different aspects of brain development, ranging from neural migration shortly after conception, to myelination, to protein production resulting from mRNA transcription and translation processes (see Batshaw, Roizen, & Lotrecchiano, 2013). Thus, even though a student might respond to instruction (RTI) at the behavioral level at a particular time in schooling, with resultant epi-genetic effects (see Cassidy, 2009), the remaining genetic vulnerability in DNA sequencing may surface again and continue to affect RTI as the nature of curriculum and academic requirements change across schooling.

Thus, the purpose of the current research was to investigate two kinds of individually administered measures that might be used as predictors of a reasonable level of achievement in specific reading and writing skills in a sample of typically developing language learners who exhibit normal variation. One predictor used was verbal reasoning, for which there is prior evidence that it is related to reading and writing achievement (e.g., Greenblatt, Mattis, & Trad, 1990; Prifitera, Weiss, Saklofske, & Rolfhus, 2005; and Vellutino, Scanlon, & Tanzman, 1991). The second set of predictors was evidence-based phenotypes for verbal working memory components supporting language learning, for which there is prior evidence that they are related to reading and writing achievement (e.g., for review, see Berninger et al., 2006; Berninger & Richards, 2010). The amount of variance explained in specific reading and writing outcomes was examined at two grade levels representative of early childhood (second grade) and middle childhood (fifth grade). The rationale for the predictors used at each of these representative grade levels is explained in the sections that follow.

1.1. Predictors

1.1.1. Verbal reasoning

Early in the 20th century the French government passed a law requiring all French children to attend school and commissioned Binet and his colleague Simon to develop measures that would identify those who might learn more quickly and need to progress more quickly as well as those who might learn more slowly and need specialized assistance (Myers, 2004). The use of these assessment measures spread to the United States, where they were developed further (Binet & Simon, 1916). Although those who developed these assessment instruments never thought a single score could address this issue of identifying individual differences in rate of learning (Myers, 2004), the use of a single score referred to as IQ for Intelligent Quotient became common educational practice. In the United States these scores were used to establish expected level of achievement for purposes of placement in programs for gifted education or special education (intellectual disabilities or specific learning disabilities).

However, research has not supported the use of IQ-achievement discrepancy for identification of specific learning disabilities (e.g., Francis et al., 2005). To begin with, although originally the single score was a quotient based on measured intellectual age compared to chronological age, test developers developed standard scores that could be compared across ages in reference to the normal bell shaped curve and abandoned use of quotients. Thus, the term IQ is not accurate and should not be used. Even though raw scores improve with age, relative performance on standard scores compared to age peers may stay the same, decline, or improve across age. Moreover, no single amount of discrepancy has ever been found that differentiates those who do and do not have specific learning disabilities; at most full scale scores may be used to differentiate those who are and are not developing in the typical range (e.g., Silliman & Berninger, 2011). Finally, a number of studies employing factor analyses identified reliable factors within the widely used Wechsler Scales—Verbal Comprehension[1], Perceptual Organization, Working Memory, and Processing Speed—in the most recent 4th Edition. Thus, the publishers of the Wechsler Scales, 4th Edition recommend use of the Index scores for these factors rather than the full scale score (see Prifitera et al., 2005). Of the four index scores, the one now referred to as Verbal Comprehension was found to be the best predictor of reading achievement in both referred (e.g., Greenblatt et al., 1990) and unreferred (Vellutino et al., 1991) samples. A cut-off criterion set at the border between average and low average range was found in one multi-generational family genetics study to be effective in differentiating learning problems in those with dyslexia (Verbal Comprehension Factor at or above standard score of 90 or the 25th %tile) and learning problems due to other neurogenetic disorders such as Fragile X) (e.g., Raskind et al., 2005).

Thus, the Verbal Comprehension Index on the Wechsler Scale was used as a predictor in the current study, which focused on written language learning. However, it is not clear whether this Index Score is purely cognitive, as subtest measures on the Wechsler Scale are assumed to be, or purely Verbal, that is, language-based, as implied by their name. As explained by Stahl and Nagy (2005), semantics or word meaning does not belong solely to the language or cognitive domain. Vocabulary involves the complex, seldom one-to-one relationships between the concepts to which words point and the use of words to express the concept. For example, the same spoken or written word can have multiple meanings, which sometimes can be referenced with a one word synonym but often require use of multiple words to explain precisely one of the meanings, as listed in unabridged dictionaries. For further discussion of this reconceptualization, which suggests that what is really being measured is the cognitive ← → linguistic translation process that can occur at any of multiple levels of language ranging from words to multi-word clausal or idiomatic constructions or text structures, see Berninger, Rijlaarsdam, and Fayol (2012).

Indeed a task analysis of each subtest contributing to the Verbal Comprehension Index suggests that something different from pure reasoning with language is being assessed. For similarities, the child has to translate concepts underlying named words into a word or phrase expressed in oral language. For vocabulary, the child has to explain the meaning of a named word by choosing words and constructing phrases and/or syntax expressed in oral language. For verbal comprehension, the child has to answer a question that requires both accessing knowledge of the real world and expressing that knowledge in words, phrases, and syntax expressed in oral language. None of these tasks require solving problems with or about language. Rather, this ability to express concepts in the cognitive domain with different levels or units of language may predict level of achievement in specific reading or writing skills, which also draw on the cognitive ← → linguistic translation process.

1.1.2. Working memory components supporting verbal learning

Research has also shown that working memory is necessary to support learning to read and write in typically developing language learners (e.g., Swanson, 1992; Swanson & Berninger, 1995, 1996a, 1996b). However, research does not support the practice of assessing working memory that supports language learning based on a single measure (Swanson, 1996). Decades of research had led to refinement of the concept of working memory, which has evolved (Baddeley, 2002, 2003). Converging evidence supports a multi-component system: (a) storage and processing units for word forms and syntax[2], (b) phonological loop for integrating internal codes with output systems through mouth and orthographic loop for integrating internal codes with output systems through the hand, and (c) supervisory attention that regulates working memory processes (for review, see Berninger & Richards, 2010).

[1] The WISC 4 Verbal Comprehension Scale measures the same construct referred to as verbal reasoning in the research on the most predictive cognitive measures for academic achievement.

[2] In the cognitive psychology and working memory research literature, coding refers to both storage and processing of words and other larger units of language (e.g., accumulating words in sentence syntax or text). [3]As heard and/or viewed single words accumulate in serial order, each is stored in working memory while the processing involved in constructing the sentence syntax unfolds over time.