



Adults with poor reading skills: How lexical knowledge interacts with scores on standardized reading comprehension tests



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ABSTRACT

Millions of adults in the United States lack the necessary literacy skills for most living wage jobs. For students from adult learning classes, we used a lexical decision task to measure their knowledge of words and we used a decision-making model (Ratcliff's, 1978, diffusion model) to abstract the mechanisms underlying their performance from their RTs and accuracy. We also collected scores for each participant on standardized IQ tests and standardized reading tests used commonly in the education literature. We found significant correlations between the model's estimates of the strengths with which words are represented in memory and scores for some of the standardized tests but not others. The findings point to the feasibility and utility of combining a test of word knowledge, lexical decision, that is well-established in psycholinguistic research, a decision-making model that supplies information about underlying mechanisms, and standardized tests. The goal for future research is to use this combination of approaches to understand better how basic processes relate to standardized tests with the eventual aim of understanding what these tests are measuring and what the specific difficulties are for individual, low-literacy adults.

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1. Introduction

The number of adults in the United States who have only the lowest of literacy skills is staggeringly high (The National Center for Education Statistics; Baer, Kutner, & Sabatini, 2009; Greenberg, 2008; Kutner, Greenberg, & Baer, 2006; Miller, McCardle, & Hernandez, 2010). The International Adult Literacy Survey Institute (2011) found that about 23% of adults in the United States read prose at the lowest level scored, indicating difficulty with comprehending even the most basic textual information; the National Assessment of Adult Literacy (Kutner et al., 2006) found that 43% lack the necessary literacy skills for most living wage jobs; and the Organization for Economic Co-operation and Development (OECD, 2013) found that one in six adults, about 36 million (two-thirds of them born in the United States) have low literacy skills (the comparable figure for Japan, for example, is one in 20). As Nicholas Kristof of the New York Times put it recently (October 26, 2014), these data “should be a shock to Americans.” The Institute of Education Sciences in the United States Department of Education has made research to understand the skills these adults lack and how to teach those

skills a high priority for funding (e.g., Calhoon, Scarborough, & Miller, 2013; Miller et al., 2010). The study we report here was designed to examine the viability of one new approach to the reading comprehension problems of this population.

We used a simple lexical decision task that is often used to study word comprehension, a skill that must figure largely in reading comprehension. In the lexical decision task, participants are given strings of letters and asked to decide as quickly and accurately as possible for each string whether it is or is not a word. For college undergraduates, accuracy on this task is typically above 90% and response times (RTs) average around 700 ms. The participants in our study were students in Adult Basic Learner classes with reading comprehension levels from the fourth through seventh grades. To their data, we applied a widely-accepted model for decision-making that decomposes RTs and accuracy into the cognitive mechanisms that underlie performance, namely, Ratcliff's diffusion model (Ratcliff, 1978; Ratcliff & McKoon, 2008).

One question was which mechanisms are deficient for low-literacy readers. Another was whether the model-based analyses we conduct can give insights into performance on a standardized language placement test for low-literacy adults, the TABE (Test of Adult Basic Education). A more general aim was to provide a proof-of-concept that diffusion model analyses are capable of informing practical education issues.

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In the diffusion model, the information encoded from a stimulus is accumulated over time from a starting point to a criterion (a boundary), at which time a response is executed. For lexical decision, information accumulates toward a word boundary for “word” responses and toward a nonword boundary for “nonword” responses (Ratcliff, Gomez, & McKoon, 2004). Central to the model is that the accumulation of information is noisy – at any instant of time, the process may move toward one of the boundaries or it may move toward the other, but on average, a process will move to the word boundary for strings of letters that are words and to the nonword boundary for strings that are not. However, the noise is large enough that the incorrect boundary can sometimes be reached, resulting in an error, and that responses for the same item can reach a boundary at different times.

The model splits the decision process into three main components of processing. One is the settings of the boundaries, that is, how far they are from the starting point; this is assumed to be under the control of the individual making the decision (instructions to a participant or payoffs for one response over the other lead to adjustments in boundary settings, Ratcliff, Thapar, & McKoon, 2001, 2003; Ratcliff, Gomez et al., 2004). Another component is the quality of the information encoded from a stimulus, which determines the rate at which information is accumulated and is called “drift rate.” For lexical decision, the quality of encoded information is determined mostly by the strength with which a word is represented in lexical memory (e.g., the representation of common words is stronger than the representation of rare words and so the rate of accumulation would be faster for common words). The third component is made up of processes outside the decision process itself: the time to execute a response and the time to encode a stimulus and transform it into a representation to drive the accumulation process. These processes are combined into one parameter of the model called “nondecision” time. In the model, the same decision process – from starting point to a boundary – determines the rate at which information is accumulated and which boundary will be reached.

For the purposes of this article, drift rates are the most interesting component because they measure the quality of the information about a word that an individual knows. This offers a new level of analysis for low-literacy research in three ways. First, often studies investigate correlations between individual-difference variables such as scores on tests of short-term memory, phonemic decoding, vocabulary, and standardized tests. Some of these tests have aspects of accuracy, the number of responses correct, and time, the amount of time given to produce responses, but none of these measure directly an individual’s knowledge of words in the way the lexical decision task with a diffusion model analysis does. Second, the model can be applied to commonly used tests like those just mentioned. For example, short-term memory could be tested in a paradigm that asks individuals to decide whether or not a word was present in a just-presented list of words or vocabulary could be tested in a paradigm that asks individuals to decide which of two choices is the better match to a word’s meaning. Paradigms like these could break performance into the components of processing defined by the diffusion model. Third, the model has been used to assess what readers know about the texts they read, for example, what the referent of a pronoun is, what the relations among elements of a text are, what the appropriate information to be inferred from a text is, and what the relations between information in a text and memory are (see McKoon & Ratcliff, 2015).

In performing lexical decision, and many other tasks, individuals can trade accuracy for speed or speed for accuracy. They can make their responses faster by setting their boundaries nearer the starting point, thus increasing the probability that the accumulated information will reach the wrong boundary. They can make

their responses more accurate by setting their boundaries farther apart, thus making their responses slower.

In studies with low-literacy adults in the education literature, the speed/accuracy tradeoffs that individuals adopt and how these tradeoffs relate to underlying components of processing have not been explicitly considered. Understanding these tradeoffs is essential: An individual may respond with low accuracy to test items because the quality of the information encoded from the items is poor or because the quality of the information is good, but the boundaries are set close together. An individual may respond slowly to test items because the quality of the encoded information is poor or because it is good but the boundaries are set far apart. Another way to say this is that individuals with the same speed may have differences in accuracy and therefore differences in underlying mechanisms, and individuals with the same accuracy may have differences in speed and therefore differences in underlying mechanisms. It is these considerations that require speed and accuracy to be explained in concert and it is these considerations that require a model like the diffusion model to separate an individual’s boundary settings from the quality of the information he or she encodes from a stimulus.

The importance of this separation is illustrated by applications of the diffusion model in aging research. Ratcliff et al. (2001, 2003), Ratcliff, Gomez et al. (2004), Ratcliff, Thapar, and McKoon (2007, 2010, 2011) have found that the usual aging effect – slower responses for older adults – often comes about not because the quality of the information they obtain from stimuli is less (i.e., not because their drift rates are lower) but instead because their nondecision component is slower and because they set more conservative boundaries, requiring more information to be accumulated before executing a response (e.g., Starns & Ratcliff, 2010). Thus, the frequently stated conclusion that older adults’ cognitive processes are, overall, worse than young adults’ because all cognitive processes are slowed is incorrect. In lexical decision, for example, older adults’ drift rates have been as good or better than young adults’ (Ratcliff, Thapar, Gomez, & McKoon, 2004).

In the sections below, we discuss research in education with low-literacy adults and research in cognitive psychology on word comprehension, then present the diffusion model in detail, and then describe the study we conducted.

2. Examples of multivariate research in the education literature

Many individual-difference studies in the education literature with low-literacy adults have used a psychometric approach to explore basic constructs that might contribute to the ability to understand written words. To illustrate this approach, we use three, quite recent, examples, studies by MacArthur, Konold, Glutting, and Alamprese (2010), Mellard, Fall, and Woods (2010), and Mellard, Woods, Desa, and Vuyk (2013; see also Nanda, Greenberg, & Morris, 2010, Tighe & Schatschneider, 2014). We discuss these in some detail to show the exploratory nature of the studies and to compare them to the diffusion model. The examples illustrate how psychometric approaches can differ from the diffusion model we use in this article. Those approaches look for broad, general constructs and how they are related to each other whereas the diffusion model provides analyses of the basic cognitive mechanisms that underlie comprehension skills. In other words, for constructs like those used in the three example studies, it would be possible, in principle, to use diffusion-model-like analyses to attempt to understand the mechanisms that determine performance.

In the 2010 study by Mellard et al., which had 174 participants in adult literacy classes, it was hypothesized that there are seven constructs relevant to reading comprehension: rapid automatic

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