



Comprehension in proficient readers: The nature of individual variation



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ARTICLE INFO

Article history:

Received 25 July 2016

Revision received 11 July 2017

Available online 25 August 2017

Keywords:

Reading comprehension

Individual differences

Working memory

Lexical processing

SEM

ABSTRACT

Individual-difference research on reading comprehension is challenging because reader characteristics are as correlated with each other as they are with comprehension. This study was conducted to determine which abilities are central to explaining comprehension and which are secondary to other abilities. A battery of psycholinguistic and cognitive tests was administered to community college and university students. Seven constructs were identified: word decoding, working-memory capacity (WMC), general reasoning, verbal fluency, perceptual speed, inhibition, and language experience. Only general reasoning and language experience had direct effects; these two variables accounted for as much variance in comprehension as did the complete set. Direct effects of WMC and decoding were found only when general reasoning and language experience were deleted from the models. The authors question the need to include WMC in our theories of variability in adult reading comprehension and highlight the need to understand precisely how vocabulary facilitates comprehension.

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Introduction

Reading is the primary means of knowledge acquisition in many domains; thus, the ability to construct accurate and comprehensive representations of texts has significant implications for academic performance, occupational success, and physical well-being. Reading is a complex skill, involving both domain-general and language-specific abilities. Variation in reading skill among individuals is considerable, even among university students. Understanding this variation is important for both practical and theoretical reasons. With respect to practice, it can help in the identification of individuals who struggle to comprehend texts and in the design of effective reading instruction. With respect to theory, individual-difference research is an important means of specifying the cognitive and linguistic processes that underlie reading. For example, contemporary theories of working memory (WM) and its role in language processing, both written and spoken, have their foundation in studies showing that reading span, a task that involves processing sentences while holding a set of words in memory, is linked to language processing as assessed by comprehension tests, eye-tracking, reading time, and event-related potentials (ERPs).

Although individual-difference research is critical to our understanding of variation in language processing, it can be difficult to

conduct. A significant obstacle is that performance across a variety of tasks tends to correlate (cf. Deary, 2000). Researchers develop tasks that are intended to assess participants' performance on a specific linguistic or cognitive process, such as working-memory capacity (WMC) or word-identification skill. The problem is that no task is "process pure;" they all involve multiple component processes. A particular task may be affected by one process more than another, but it is never an assessment of a single one. To the extent that processes overlap across tasks, performance on them will be correlated. Indeed, research on individual differences in reading comprehension shows that performance on individual-difference tasks correlate with each other as much as they do with reading comprehension itself. These correlations make it difficult to determine whether a particular individual characteristic (e.g., WMC) is uniquely predictive of language processing skill or if it correlates only because of its relation to some other individual-difference variable. As we discuss in the following sections, several individual-difference measures, such as WMC and word decoding, have dominated research on language processing and comprehension, even though there is scant evidence that these measures are uniquely predictive of performance. This raises significant concerns about theoretical interpretations of this research.

Our goals in the current study were (1) to understand how reader characteristics are related to each other and to text comprehension, with a particular focus on determining the extent to which WMC, vocabulary, and word knowledge are uniquely predictive of comprehension, and (2) to examine how these relations change depending on which reader characteristics are included in

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the analysis. We used a structural equation modeling framework in a group of proficient adult readers to determine which reader characteristics are central in predicting comprehension and which are related by means of shared variance with other characteristics. Few large-scale studies of comprehension in proficient adult readers have been conducted even though several theories about the nature of individual variation in reading ability have been developed based on empirical findings in this population (e.g., Ericsson & Kintsch, 1995; Gernsbacher, 1990; Just & Carpenter, 1992; MacDonald & Christiansen, 2002). In the sections below, we review the literature on three classes of variables: domain-general cognitive abilities, language-specific abilities, and background knowledge/reading experience. We focus our review on large-scale multiple-regression and SEM studies of proficient adult readers whenever possible.

Domain-general cognitive abilities

No single cognitive ability has received as much empirical and theoretical attention as WMC. Many researchers have argued that the WM system is integral to maintaining activated representations and computing semantic and syntactic relations among them. Moreover, they have argued that individuals vary in the amount of information that they can maintain in memory as they perform computations to complete a complex cognitive task. These claims are supported by hundreds of studies showing a positive correlation between complex span tasks, such as reading span, and tests of verbal ability such as the verbal SAT and the Nelson-Denny Reading Test. Daneman and Merikle (1996) conducted a meta-analysis of the relation between complex span tasks and verbal ability and reported correlations across studies that ranged from .20 to .52. Studies in which WMC has been assessed as a latent variable have also found a significant relation between WMC and comprehension (Engle, Tuholski, Laughlin, & Conway, 1999; McVay & Kane, 2012).

Several explanations of the correlation between complex span and comprehension have been developed in the context of sentence-processing research to explain why some readers have greater difficulty processing sentences with complex syntactic structures than do other readers. These explanations are all grounded in the assumption that difficulty in processing sentences has consequences for comprehension overall. Explanations for the correlation between span and language processing generally fall into two classes: (1) those in which the relation between span and processing is a direct one in that limitations in the ability to simultaneously maintain and process information affect the types of relations that readers are able to construct during comprehension and (2) those in which the relation between span and processing is indirect in that the correlation reflects shared variance between span tasks and other variables, in particular, language experience.

A direct relation between complex span and comprehension is predicted in two models: the Capacity Theory of Comprehension (Just & Carpenter, 1992) and the Separate-Sentence-Interpretation-Resource Theory (SSIR) (Waters & Caplan, 1996). According to Capacity theory, WM consists of a finite pool of cognitive resources that supports both storage and processing of information. The total amount of activation that is available in WM varies across individuals. When the amount of activation that is needed for storage and processing exceeds the total activation that is available, one or both functions are impaired and information is lost. Thus, individuals who are low span have insufficient resources to execute necessary comprehension processes when storage and processing demands are high as, for example, when readers encounter syntactically difficult sentences (Just & Carpenter, 1992; King & Just, 1991). The SSIR Theory differs from Capacity

Theory with respect to predictions about the role of WMC in sentence processing, but not with respect to predictions about text comprehension. According to this view, WMC is modular with a dedicated module devoted to syntactic parsing and a second module that is devoted to post-parsing processes involved in the integration and elaboration of ideas in comprehension. Individuals show little variation in the capacity of the first module, but vary substantially in the capacity of the second. Thus, SSIR Theory is similar to Capacity Theory in attributing individual differences at the discourse level to a limited-capacity system.

In contrast, an indirect relation between WM span and comprehension is predicted in a connectionist-based framework proposed by MacDonald and Christiansen (2002) and the Long-Term Working-Memory (LTWM) Theory proposed by Ericsson and Kintsch (1995). According to the connectionist-based framework, the capacity of a system arises from its architecture (e.g., the number of processing units, how activation passes through the weights) and the system's experience (e.g., how often it has processed similar input in the past). Thus, capacity is not a separate pool of resources; it is a property of the processing system. The relation between complex span and comprehension arises from variation in two factors. First, individuals vary with respect to basic sensory/perceptual abilities, primarily the ability to represent and process phonological information. The ability to discriminate phonemes quickly and represent them accurately in short-term memory is important in grapheme-to-phoneme mapping during reading and for performing well on verbal span tasks. Second, individuals vary in reading experience, giving rise to individual differences in practice with linguistic stimuli. Poor comprehenders read less frequently than do good ones; thus, they are less likely to encounter low-frequency linguistic stimuli (e.g., uncommon syntactic structures). Consequently, variation in the processing of low frequency input is due to differences in practice (Long & Prat, 2008; Wells, Christiansen, Race, Acheson, & MacDonald, 2009). The LTWM Theory also emphasizes the role of experience in explaining the relation between complex span and comprehension. According to the theory, skilled readers develop mechanisms for encoding and retrieving information from long-term memory that meet the demands of the task. Thus, individuals who read frequently are skilled at encoding linguistic input into structures that can be quickly and easily retrieved when needed.

Although WM span has been used in hundreds of studies to predict language processing in proficient adult readers, only a handful of them have examined whether or not span is uniquely predictive of comprehension when other linguistic and cognitive variables are considered. Does span have a direct relation on comprehension as predicted by the Capacity and SSIR Theories or is the relation indirect as predicted by the connectionist-based and LTWM Theories? In one study, Hannon (2012) found that WMC had a significant effect on comprehension using an SEM approach. She assessed high-level skills (e.g., knowledge access, knowledge integration) and low-level skills (e.g., lexical decision, phonological decision). The model, the Cognitive Components and Resource Model of Reading Comprehension (CC-R), was restricted such that low-level skills (e.g., word decoding) directly predicted both reading speed and reading comprehension; reading speed directly predicted reading comprehension; WMC, text-based processing, and knowledge access directly predicted knowledge integration; and knowledge integration directly predicted reading comprehension. A variant of the model, the CC-R2, allowed WMC to have a direct effect on reading comprehension and was found to be the best fitting one. Hannon concluded that high-level and low-level skills are dissociable and that high-level skills have a greater impact on comprehension than do low-level ones. A critical drawback of the study in assessing the role of WMC in comprehension, however, is that latent variables in the model were not allowed to covary although

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