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The component processes of reading comprehension in adolescents

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ABSTRACT

In the present study we focus on the component processes of reading comprehension in adolescents. To accomplish this we applied the component processes task (CPT, Hannon & Daneman, 2001) in two connected studies to assess higher-level reading comprehension processes and the cognitive-components-resource (CC-R, Hannon, 2012) model to structure the pattern of relationships between word-level and higher-level processes, working memory, and reading comprehension. Our results indicate that the component processes of reading comprehension can be differentiated in German speaking adolescents and that approaches such as the CC-R are suitable for modeling individual differences in their comprehension processes. The pattern of relationships between processes and cognitive resources was found to be comparable between girls and boys as well as L1 and L2 German speakers, although mean differences were found in both comparisons.

1. Introduction

Comprehending written text is a complex cognitive task. A reader must decode individual words, identify connections between them and integrate their meanings in the overall structure of clauses, sentences, and paragraphs. However, the information provided by a text is not necessarily complete—connections between words or phrases may be implicit or require prior knowledge. To understand how a reader derives meaning from written text we therefore need models of reading comprehension which differentiate between different relevant processes. Much attention has been devoted to investigating the significance of different cognitive processes which contribute to individual differences in comprehension outcomes (see Zwaan & Radvansky, 1998; McNamara & Magliano, 2009 for reviews). Viewing the construction of a comprehensive mental model of a text (Kintsch, 1988, 1998) as the product of different cognitive processes allows both differentiated theoretical and empirical approaches to modeling reading comprehension. Theoretically, lower-level word decoding (Hoover & Gough, 1990; Gough, Hoover, Peterson, Cornoldi, & Oakhill, 1996; Perfetti & Hogaboam, 1975; Perfetti, 1985), general verbal capacities such as vocabulary (Ouellette, 2006; Tunmer & Chapman, 2012) and working memory (Daneman & Merikle, 1996), as well as higher-level processes which integrate text-based information and relevant knowledge stored in memory (Hannon & Daneman, 2001) are argued to influence reading comprehension. Empirically, models such as the Cognitive-Components-Resource (CC-R) model are able to test the individual contributions of different cognitive processes to text comprehension (Hannon, 2012). The CC-R approach thus provides a model of the contribution of individual differences in word and sentence level processing, working memory capacity, and higher-level comprehension processes on individual differences in reading comprehension. This approach has further been used to test the effects of individual differences such as years of schooling (August, Francis, Hsu, & Snow, 2006), gender (Hannon, 2014), and language background (August et al., 2006; Francis et al., 2006) on the interplay of different component processes of reading comprehension. The aim of the present study is to extend these findings by applying the CC-R model to data collected on adolescent readers and to assess the model for gender and language group differences.

In the two studies presented here we focus on the component processes of reading comprehension in adolescents which have received the least attention in the comprehension literature. As previous studies have shown a greater differentiation of cognitive processes leading to successful reading comprehension in experienced adult readers (Hannon & Daneman, 2001, 2007; Hannon, 2012, 2014) than beginning readers (August et al., 2006; Hannon & Frias, 2012; Francis et al., 2006), we expected adolescents to show an intermediate differentiation of component processes and tested this hypothesis in Study 1. We then used the CPT in Study 2 as an element of the CC-R model to structure the relationships between word-level and higher-level processes, working memory, and reading comprehension in adolescents. In Study 2 we also made use of the CC-R modeling approach to test for group differences in the cognitive processes involved in reading comprehension in adolescents between girls and boys, as well as L1 and L2 German speakers.

1.1. Component processes of reading comprehension

Since the 1980s, the concept of reading comprehension has shifted from the decoding and storage of information to the construction and

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updating of a mental representation of a text. The mental representation is constructed by decoding and linking information about a state of affairs described in a text which is enriched with relevant prior knowledge to form a more elaborate and durable situation model representation (Kintsch, 1988, 1998). An abundant and growing body of empirical evidence indeed suggests that reading relies on multiple processes which each explains unique variance in individual differences in reading comprehension (Hannon, 2012; Cain, Oakhill, & Lemmon, 2004; Jenkins, Fuchs, van den Broek, Espin, & Deno, 2003; Oakhill, Cain, & Bryant, 2003; Hannon & Daneman, 2001). These processes may be divided into three groups of variables, including word-level decoding processes and processing speed, general verbal capacities such as verbal working memory, and higher-level component processes which generate inferences and integrate new information with prior knowledge.

Word-level decoding processes provide the most basic information about the identity and meaning of words which is necessary for the understanding of propositional phrases and identifying explicitly stated semantic and syntactic connections between them. There is also evidence that individual differences in the mastery of word-level processes influence reading comprehension skill (Holmes, 2009; Jenkins et al., 2003). Consistent with verbal efficiency theory (Bell & Perfetti, 1994; Perfetti, 1985), this suggests that efficient word-level processes leave more cognitive resources available for higher-level comprehension processes. Conceptually, word decoding is the necessary starting point for text comprehension, as repeated decoding of words may both function as a learning mechanism for new words (e.g., self-teaching hypothesis, Share, 1995) as well as a means to consolidate the connections between phonology, orthography, and semantics in the mental lexicon (e.g., lexical quality hypothesis, Perfetti, 2007). Indeed, the quality of orthographic and phonological mental representations appear to be requisite for high quality semantic representations of words and the accuracy of all three kinds of representations explain a large proportion of individual differences in reading comprehension (Richter, Isberner, Naumann, & Neeb, 2013). Nevertheless, higher-level cognitive processes are necessary to connect word meanings with grammatical and narrative structures and combine these with a reader's world knowledge to create a comprehensive representation of the content of a text (Perfetti & Stafura, 2014).

Working memory represents a capacity both for processing and temporary storage of information (Baddeley & Hitch, 1974). With respect to reading, verbal working memory capacity allows a reader to keep syntactic, semantic and pragmatic information active which can then be used to process later text passages, thus facilitating reading comprehension (Daneman & Carpenter, 1980; Daneman & Merikle, 1996). The extensive meta-analysis conducted by Daneman and Merikle (1996) clearly showed the importance of the processing and storage capacity of working memory for reading comprehension. Higher-level comprehension processes are assumed to depend on these resources to retain text information in active memory while new information is being processed, allowing the integration of text information across sections of a text, as well as with relevant prior knowledge (Daneman & Hannon, 2007).

Higher-level processes draw on word-level information and cognitive resources to generate inferred connections between phrases and integrate relevant prior knowledge to enrich the mental representation with information not provided by the text. These higher-level processes—and the cognitive capacities on which they draw—are argued to be critical for the construction of an elaborated mental representation and comprehension of a text (Hannon, 2012; Hannon & Daneman, 2001; Kintsch, 1998). The component processes task (CPT, Hannon & Daneman, 2001) is an instrument specifically developed to tap higher-level comprehension processes of inference generating, knowledge activation, and integration. Hannon and Daneman (2001) presented readers with scenarios in which relationships between three real and three imaginary entities were described in short sentences (e.g., a BREG is heavier than a BEAR/a SPOG is lighter than a FOX). After studying the sentences participants were asked to respond to true/false statements about the scene, of which half were false. Text memory statements tested accurate recall of verbatim text information, while text inferencing statements tested whether relationships between entities could be inferred, based on explicit text information (e.g., a BREG is heavier than a SPOG). Knowledge access statements assessed whether participants accessed knowledge which did not require text-based information (e.g., a FOX is lighter than a BEAR). Finally, knowledge integration statements required the integration of knowledge stored in memory and text-based information (e.g., a BREG is lighter than an ELEPHANT). In a series of four experiments, Hannon and Daneman (2001) demonstrated that the four components of text memory, text inferencing, knowledge access, and knowledge integration, together with processing speed, account for a large amount of variance in global reading comprehension measures. The CPT was also shown to account for more variance in reading comprehension than either vocabulary knowledge or working memory on their own. The CPT hence distinguished between processes which access relevant prior knowledge and those which extract information from a text, generate inferences based on this information, and finally integrate verbatim and inferred text-based information with activated prior knowledge. In skilled adult readers these processes appear to form three clusters, combining text memory and text inferencing into a text-based component and the separate components processes of knowledge access and knowledge integration (Hannon, 2012).

1.2. The cognitive component-resource model

The relationship between component processes and other cognitive processes has been investigated in a series studies (Daneman & Hannon, 2007; Hannon & Daneman, 2001; Hannon, 2012, 2014). The most elaborate of these models, the Cognitive-Components-Resource model (CC-R, Hannon, 2012), proposes a structure of relationships between higher- and lower-level component processes and limited capacity cognitive resources necessary for successful comprehension during reading. The CC-R model makes five assumptions about the relationships between reading comprehension processes, based on earlier findings, which allows the structure of the model to be tested empirically. The first assumption is that word-level and higher-level comprehension processes are distinct constructs in experienced readers. Word decoding and identification are therefore assumed to be separate from processes which connect concepts and infer relationships between propositional phrases which are not explicitly stated in a text. The second assumption states that the higher-level comprehension processes can be differentiated into separate cognitive processes. Similar to the construction–integration concept (Kintsch, 1988), construction processes activate relevant knowledge from memory and the text while integration processes allow the combination of extracted concepts with each other and with related concepts stored in memory. The third assumption is that readers form a mental representation of a text during reading. The quality of this representation varies depending on the efficiency of word-level and higher-level processes as well as available working memory capacity. The fourth assumption presupposes that word-level processes do not draw on working memory capacities and do not directly influence higher-level processes in experienced readers. Finally, the fifth assumption states that working memory provides the cognitive resources required to drive higher-level comprehension processes. The influence of working memory capacity on reading comprehension is therefore predominantly indirect through the mediation of higher-level processes.

The differentiation of component processes of text memory, text inferencing, knowledge activation, and knowledge integration to reading comprehension has been shown, using adaptations the CPT, for adult readers (Hannon, 2012; Hannon & Daneman, 2001), primary school children (August et al., 2006; Francis et al., 2006), and preschoolers (Hannon & Frias, 2012). Generally, the results of these studies