Monitoring the coherence of texts : coherence-break detection across development

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1 | General Introduction

This chapter is partly based on

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and

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1.1 Understanding texts

The ability to read and understand texts is essential in school as well as in daily life. Many aspects in life require comprehension of texts. For example, communicating through e-mail or social media, filling out forms, following instructions in manuals, learning from text in school books, reading a novel for fun, and so on. To be able to understand texts is not only important, it is also a complex ability, requiring a reader to engage in a combination of cognitive processes at various linguistic levels. For example, letters need to be decoded into sounds, which are combined into words, which are units of sentences, which make up paragraphs et cetera. An often made categorization of levels of cognitive processes related to reading is the distinction between *basic* and *higher-order* reading skills and processes (Gough & Tunmer, 1990; Kendeou, van den Broek, Helder, & Karlsson, 2014; Language and Reading Research Consortium, 2015). Basic reading processes refer to processes related to translating the written code into meaningful units of information, such as phonological, orthographical and semantic processes (e.g., de Jong & van der Leij, 1999; Ehri, 2005; Perfetti, 2007). Higher-order reading processes refer to processes that allow a reader to combine these meaningful units into a coherent mental representation of the text (e.g., Graesser, Singer, & Trabasso, 1994; Kintsch, 1998; Perfetti & Stafura, 2014; van den Broek, 1994). Both basic and higher-order reading processes are executed within a reader's limited working-memory capacity (Engle, 2002; Just & Carpenter, 1992; Kintsch & van Dijk, 1978). The relative contribution of both levels of reading processes to children's comprehension of texts changes across development: The variance in reading-comprehension performance explained by basic reading processes decreases with age, whereas the variance of reading comprehension explained by higher-order reading processes increases with age (Adlof, Catts, & Little, 2006; Hogan, Adlof, & Alonzo, 2014; de Jong & van der Leij, 2002; Kendeou, van den Broek, White, & Lynch, 2009). The studies described in this thesis focus on higher-order processes related to constructing coherence during reading of texts, one of the most important skills to be mastered over the course of development.

1.2 Constructing a coherent mental representation

Central to many theories on reading comprehension is the notion that readers construct a mental representation of a text that consists of what the text is about, rather than a recollection of the exact words and sentences (Graesser, et al., 1994; Kintsch 1998; van den Broek, 1994, for a review on influential theoretical models see McNamara & Magliano, 2009). To examine how readers construct such a coherent mental representation and to gain insight into the underlying mechanisms of successful reading comprehension, it is useful to make a distinction between products (what is stored in the reader's mental representation of the text after reading, i.e., *offline*) and processes (the cognitive processes a reader engages in during reading, i.e., *online*) of reading comprehension.

The *product* of the reader's cognitive processes during reading, the mental representation, can be thought of as a conceptual network consisting of text elements and their meaningful relations inferred by the reader (e.g., Graesser & Clark, 1985; Kintsch, 1988; Trabasso, Secco, & van den Broek, 1984). Within a network, elements differ in their contribution to overall coherence. For instance, some text elements have many semantic connections to other text elements, whereas others have only a few. Readers' mental representations of texts tend to be structured around information that is central, i.e., that connects different elements in a text and, by doing so, readers create coherence. Thus, readers are sensitive to structural centrality (for a review see van den Broek, Helder, & Van Leijenhorst, 2013). For example, readers typically recall text elements with many connections more frequently, rate them as more important, and include them in summaries more often than text elements with few connections (e.g., Graesser & Clark, 1985; O'Brien & Myers, 1987; Trabasso & van den Broek, 1985; for reviews, see Traxler & Gernsbacher, 2006; van den Broek, 1994). The degree to which readers selectively process and represent statements that are highly connected and thereby are structurally central to the text's coherence increases over the course of development. For example, children as young as 4 years of age are able to infer semantic relations into their mental representation and show to be sensitive to structural centrality after watching televised *Sesame Street* stories well before formal reading instruction begins (van den Broek, Lorch, & Thurlow, 1996). This sensitivity gradually increases with age (van den Broek, 1989; van den Broek, Young, Tzeng, & Linderholm, 1999).

What is encoded into a reader's mental representation is a consequence of the cognitive *processes* a reader –automatically or strategically– engaged in during reading. For example, during reading, readers generate inferences between text elements as well as between text elements and their background knowledge (e.g., Kintsch, 1988; Trabasso & van den Broek, 1985; for a recent overview see O'Brien, Cook, & Lorch, 2015), activate and integrate relevant information and inhibit irrelevant information (e.g., Borella, Carretti, & Pelegrina, 2010; Diamond, 2013; van den Broek, Young, Tzeng, & Linderholm, 1999), and monitor whether what they read makes sense (e.g., Baker, 1985; Helder, Van Leijenhorst, & van den Broek, 2016; Oakhill, Hartt, & Samols, 2005; Zabrucky & Ratner, 1986). This last process, coherence monitoring, is especially important for successful comprehension, because it functions as a gatekeeper to secure coherence and enables the reader to adapt engagement in any cognitive processes to restore coherence.

1.3 Monitoring coherence by detecting coherence breaks

Coherence monitoring refers to the cognitive processes related to maintaining coherence during reading, as well as to the cognitive processes related to noticing when coherence is disrupted. Most readers would recognize the following situation. After a long day, you finally started to read the novel you have been wanted to read for a long time. When you are halfway through the third page you notice that you do not remember whether the name that is mentioned refers to the brother or to the husband of the protagonist; you have detected a break in coherence. Whether it refers to the brother or the husband is likely to be highly relevant for the story line that unfolds and, thus, for the degree of coherence of your mental representation of the novel that is constructed during reading.

As a reader proceeds through a text, each incoming piece of information elicits an automatic and unrestricted spread of activation through a reader's memory (e.g., Cook & O'Brien, 2014; Gerrig & O'Brien, 2005; Kintsch, 1988; McKoon & Ratcliff, 1992). If the activated information is consistent with information from the current sentence and/or with the emerging mental representation, coherence is maintained. Conversely, if the activated information contradicts the information that is currently read from the text or cannot be integrated in the emerging mental representation, coherence is disrupted. If a reader successfully monitors the coherence of an unfolding text, such breaks in coherence are detected during reading. This provides the reader with the opportunity to regulate his/her reading behavior to resolve the inconsistency (Baker & Brown, 1984; Zabrucky & Ratner 1986), for example by rereading parts of the text, by applying background knowledge, or otherwise trying to restore coherence (Duke & Pearson, 2002).

The ability to monitor the coherence of one's mental representation changes with age. On the one hand, over the course of development readers apply their developing comprehension skills to increasingly complex texts (McNamara, Graesser, & Louwerse, 2012; Evers-Vermeul & van der Hoeven, 2015). On the other hand, because of younger children's need to attend to basic reading processes they may have relatively fewer cognitive resources available for higher-order reading processes such as coherence monitoring, whereas older children's basic skills may be more automatized, leaving more cognitive resources available for coherence monitoring (Kendeou, Papadopoulos, & Spanoudis, 2012; Perfetti, 1985; 2007).

In this thesis we examined coherence-monitoring processes by readers between the ages of 8 and 27 by measuring their ability to detect coherence breaks during reading of short narratives. We have adapted the contradiction paradigm developed by O'Brien and colleagues, which is frequently used in studies that examined the availability of information during reading in adults (e.g., Albrecht & O'Brien, 1993; Cook, Halleran, & O'Brien, 1998; Long & Chong, 2001; Myers, O'Brien, Albrecht, & Mason, 2004; O'Brien, Rizzella, Albrecht, & Halleran, 1998). In this paradigm participants read narratives sentence-by-sentence on a computer screen in a self-paced manner. Readers are instructed to read for comprehension and answer questions that follow each narrative; thus, they are not explicitly asked about possible contradictions. Reading times for each sentence are recorded. Some of the narratives contain a semantic contradiction between information presented early in the text and information presented in a target sentence later in the text, whereas other narratives do not. An example from one of the experimental materials used in this thesis is a narrative in which two brothers are introduced who spend a day at home. The target sentence presented at the end of the narrative states that they build a snowman in the backyard. In the coherent condition, this target sentences is preceded by the context information that the boys spend a day at home in Winter, whereas in the incoherent condition they spend a day at home in Summer (adapted from Albrecht & O'Brien, 1993). When reading times for target sentences from coherent narratives are compared to those from incoherent narratives, readers usually show a so-called inconsistency effect: processing incoherent target sentences takes more time compared to processing coherent target sentences. This difference in reading times reflects coherence-break detection during reading (Gerrig & O'Brien, 2005; O'Brien, Cook, & Gueraud, 2010).

The contradiction paradigm is a powerful way to examine coherence-monitoring processes for several reasons. *First*, detecting coherence breaks during reading is a critical first step in monitoring the coherence of an emerging mental representation of a text, the essence of reading comprehension. If coherence breaks are not detected, there is also no possibility to adapt reading behavior to restore coherence and comprehension is likely to be limited. *Second*, the contradiction paradigm has proven to be a powerful tool to examine whether readers detect coherence breaks during reading. As mentioned above, most of previous studies that have used this paradigm investigated coherence-break detection processes in young adults, i.e., undergraduate (psychology) students (e.g., Albrecht & O'Brien, 1993; Cook et al., 1998; Long & Chong, 2001; Myers et al., 2004; O'Brien et al., 1998). Likewise, several variations of the contradiction paradigm have been used in elementary-school children (e.g., Baker 1984; Connor et al., 2015; Ehrlich, Rémond, & Tardieu, 1999; Kinnunen & Vauras, 1995; Oakhill, Hartt, & Samols, 2005; van der Schoot, Reijntjes, & Van Lieshout, 2012; Zabrucky & Ratner, 1986), some in the first half of adolescence (Bohn-Gettler, Rapp, van den Broek, Kendeou, & White, 2011; Cataldo & Cornoldi, 1998; Hacker, 1997), and relatively little in the second half of adolescence (Barth et al., 2015). However, there are indications that processes related to coherence-monitoring are gradually developing with age, such as inference making (van den Broek, 1997) and cognitive-control processes (Diamond, 2013; Huizinga, Dolan, & van der Molen, 2006; Luna, Garver, Urban, Lazar, & Sweeney, 2004). Thus, we chose to adapt the contradiction paradigm as used in the adult literature to build on previous studies and to contribute to the developmental literature on coherence monitoring by examining coherence-break detection processes using the same method across development in a wide age range (ages 8-22). *Third*, because the inconsistency effect has been replicated numerous times in behavioral studies, the contradiction paradigm serves as a solid foundation to explore the neural bases of cognitive processes in response to coherence breaks. Insight into the brain mechanisms in response to coherence breaks provides additional information to reading-time data and may be sensitive to potential developmental and individual differences that could not be picked up by behavioral measures alone.

1.4 Outline of this dissertation

The central aim of this dissertation is to examine coherence-monitoring processes and, more specifically, the cognitive processes related to the detection of coherence breaks during reading across development.

The first part of this dissertation consists of three empirical studies (**chapter 2-4**) with the overarching goal to examine readers' engagement in coherence-monitoring processes during reading across development. In all studies we used an adaptation of the contradiction paradigm (Albrecht & O'Brien, 1993) to investigate whether readers of various ages detected coherence breaks during reading. Participants were presented with short narratives that in half of the trials contained a break in coherence such that information presented in a target sentences semantically contradicted information presented earlier in the text, whereas the same target sentence in the other half of the trials did not. Reading times were compared between incoherent and coherent target sentences. The aim of the study described in **chapter 2** was to examine whether children in two age groups (8-9 years vs 10-11 years) with good and poor reading-comprehension ability differ in their coherence-monitoring skills by measuring whether they detected coherence breaks *during* reading (online) and/or encoded them in their mental representation *after* (offline) reading. Results from this first behavioral study motivated the formulation of the research aim for a second behavioral study (**chapter 3**): To examine whether coherence-monitoring processes continue to develop in adolescence. In this study the textual distance (i.e., the number of filler sentences) between contradictory pieces of information was varied by adapting experimental materials used in the first behavioral study. The influence of textual distance on the likelihood that coherence breaks are detected during reading was compared between younger (ages 10-14) and older adolescents (ages 16-22). In the study described in **chapter 4** we took another approach by examining the neural correlates of the detection of coherence breaks using the same experimental materials as described in chapter 2. It could be that behavioral measures, such as reading times, are not sensitive enough to pick up subtle developmental differences, whereas a measure of brain activation, which reflects the origin of the cognitive processes involved in reading comprehension, might be sensitive to such differences. The first goal was to explore young adults' neural responses to coherence-break detection while simultaneously obtaining a behavioral measure of coherence-break detection. Participants' brain activation in response to incoherent target sentences was compared to their brain activation in response to coherent target sentences, resulting in a network of brain regions related to coherence-break detection. An additional goal was to examine individual differences in brain activation related to coherence-break detection. Specifically, we examined whether activation in the coherence-break detection network differs as a function of participants' working-memory capacity.

The second part of this dissertation consists of a theoretical account on the sources of comprehension problems during reading (**chapter 5**) and takes a broader perspective by describing three factors and cognitive processes contributing to developmental change as well as individual differences in reading comprehension: 1) factors and processes related to general cognition, such as executive functioning and background knowledge, 2) factors and processes related to comprehension, such as constructing coherence out of incoming information, independent from input modality, i.e., text, movies, conversations, 3) factors and processes specifically related to the comprehension of written text, such as knowledge of story structure and text genre.

Finally, in **chapter 6** the results and conclusions from the empirical studies in this dissertation are summarized and discussed in a broader context.