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

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Coherence monitoring in adolescence: The effect of textual distance on the detection of coherence breaks during reading

Abstract

Background To successfully understand texts in school it is crucial that students monitor the coherence of their mental representations of texts and detect coherence breaks during reading. This study examines the development of coherence-monitoring processes related to the detection of coherence breaks during reading in an adolescent population.

Methods Younger (*N*=46; ages 10-14) and older adolescents (*N*=40; ages 16-22) read short narratives either with or without a coherence break in a self-paced contradiction paradigm. Availability of information was manipulated by varying the textual distance between contradictory pieces of information.

Results The likelihood that prior context information is available when reading target information and, thus, that a coherence break can be detected, decreases when textual distance increases in younger adolescents, but not in older adolescents.

Conclusions Coherence-monitoring processes are still developing during the first half of adolescence and seem to be relatively mature in the second half of adolescence.

3.1 Introduction

The ability to understand the meaning of texts is one of the most important abilities to be mastered during formal education. Although this ability generally is presumed to have been accomplished by the end of elementary school, results from the Program for International Student Assessment (PISA) show that 14% of Dutch 15-year-old students fail to meet the basic standards to read and comprehend texts. The average percentage for countries associated with the Organization for Economic Co-operation and Development (OECD) is even higher (18%; OECD, 2014). The ability to understand and learn from texts is essential in school, but also in daily life, for example when reading newspapers, user manuals or filling out formal documents. To understand a text successfully, a reader constructs a mental representation that is coherent by connecting incoming information from the text with prior information and background knowledge (Graesser, Singer, & Trabasso, 1994; Kintsch, 1988; Trabasso, Secco, & van den Broek, 1984). This requires a reader to monitor continuously whether coherence is maintained during reading and to notice when coherence is disrupted (e.g., Albrecht & O'Brien, 1993; Helder, Van Leijenhorst, & van den Broek, 2016; Zabrucky & Ratner, 1986). If a break in coherence goes unnoticed by the reader, it is likely that the mental representation that the reader constructs is an inaccurate reflection of the content of the text. As a result, comprehension is insufficient and the ability to understand and learn from the text is limited.

The cognitive processes and skills involved in reading comprehension, including those related to generating inferences (Kendeou, van den Broek, White, & Lynch, 2009; Oakhill & Cain, 2012; van den Broek, 1997), monitoring the coherence of texts (Barth, Barnes, Francis, Vaughn, & York, 2015; Hacker, 1997), and coordination of the execution of comprehension-related processes by means of cognitive control (Huizinga, Dolan, & van der Molen, 2006; Luna, Garver, Urban, Lazar, & Sweeney, 2004; Sesma, Mahone, Levine, Eason, & Cutting, 2009), are gradually developing over the course of childhood and into adolescence (for a more detailed overview of the various processes involved in the development of reading comprehension see Cain & Oakhill, 2007; Helder, van den Broek, Van Leijenhorst, & Beker, 2013; van den Broek & Espin, 2012). In addition, over the course of development readers apply their developing comprehension skills to increasingly complex texts (McNamara, Graesser, & Louwerse, 2012). Previous studies on the development of coherence monitoring have focused on coherence-monitoring processes in children (e.g., Baker 1984; Connor et al., 2015; Ehrlich, Rémond, & Tardieu, 1999; Kinnunen & Vauras, 1995; Markman, 1979; Oakhill, Hartt, & Samols, 2005; van der Schoot, Reijntjes, & Van Lieshout, 2012; Zabrucky & Ratner, 1986), early adolescents (e.g., Bohn-Gettler, Rapp, van den Broek, Kendeou, & White, 2011; Cataldo & Cornoldi, 1998;

Hacker, 1997), or have compared the engagement in coherence-monitoring processes in adults to that in children or early adolescents (Ackerman, 1984; 1986; Grabe, Antes, Kahn, & Kristjanson, 1991). The results of these studies show that coherence-monitoring proficiency gradually develops and has not yet fully matured by early adolescence. However, relatively little is known about the development of coherence-monitoring proficiency in late adolescence. One possibility is that coherence-monitoring processes continue to develop gradually, until adulthood. Another possibility is that they mature during early adolescence and undergo relatively little change after that. The aim of this study is to examine the development of coherence-monitoring processes during reading in younger and older adolescents.

Adolescence is the period in which children transform into adults and roughly spans the second decade of life (Dahl, 2004; Galvan, Van Leijenhorst, & McGlennen, 2012; Spear, 2000; Steinberg, 2005). Adolescence starts with the onset of puberty, which on average starts around age 10 and characterizes the first half of adolescence (Blakemore, Burnett, & Dahl, 2010). However, the end of puberty does not mark the end of adolescence, which is less clearly defined (Arnett, 2014). During the transformation from childhood to adulthood, adolescents are becoming increasingly independent individuals both in and out of the school context (Blakemore et al., 2010; Taylor, Barker, Heavey, & McHale, 2013). In the school context, a consequence of this independence is that adolescents are increasingly expected to rely on their own reading and study skills as educational materials, including texts, are becoming more complex (Brown, Smiley, & Lawton, 1978; McNamara et al., 2012; Vaughn et al., 2008). To comprehend these increasingly complex texts sufficiently, coherence-monitoring processes become more important. Based on studies with students in elementary school (e.g., Connor et al., 2015; Eme, Puustinen, & Coutelet, 2006; Zabrucky & Ratner 1986) and students in the first half of adolescence (e.g., Bohn-Gettler, Rapp, van den Broek, Kendeou, & White, 2011; Cataldo & Cornoldi, 1998; Hacker, 1997), coherence-monitoring performance has been shown to increase with age, but relatively little is known about the second half of adolescence. Results from studies outside the field of reading comprehension show that cognitive-control processes, such as working memory, inhibition of irrelevant information, and allocation of attention to relevant information, continue to develop during the second half of adolescence into adulthood (Huizinga et al., 2006; Luna et al., 2004). Cognitive processes related to both the monitoring of coherence itself and the reader's response to a break in coherence (repair processes, rereading etc.) are likely to rely on cognitive-control processes. The protracted development of cognitive-control processes throughout adolescence could be taken to suggest that coherence monitoring continues to develop as well. In this study we make the distinction between the first half (*younger adolescents,* age 10-14) and the second half of adolescence (*older adolescents,* age 16-

22) and examine whether coherence-monitoring processes continue to develop during the second half of adolescence.

Coherence-monitoring processes refer to the cognitive processes involved in noticing when coherence is disrupted 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 this spread of activation leads to activation of information that can be integrated in the emerging mental representation, coherence is maintained. Conversely, if the activated information contradicts the information that is currently read from the text, coherence could be disrupted. If a reader successfully monitors the coherence of an unfolding text, such breaks in coherence are detected during reading. This gives the reader the opportunity to regulate his/her reading behavior by trying to resolve the inconsistency (Baker & Brown, 1984; Zabrucky & Ratner 1986), for example by rereading parts of the text, or by applying background knowledge, to restore coherence (Duke & Pearson, 2002).

Whether coherence breaks are detected during reading depends on the availability of context information from prior text and background knowledge to the reader at the moment a coherence break is encountered (Cook & O'Brien, 2014; Isberner & Richter, 2014a; Kintsch, 1988; van den Broek & Kendeou, 2008). The availability of context information at the moment target information is presented is influenced by various factors. For example, context information is more available when it was elaborated than when it was not (e.g., O'Brien et al., 1998), when context information is causally related to target information (e.g., Kendeou, Smith, & O'Brien, 2013; O'Brien & Myers, 1987; Trabasso & van den Broek, 1985), or when the textual distance between context and target information is shorter (e.g., Barth et al., 2015; Long & Chong, 2001; Myers & O'Brien, 1998; Oakhill et al., 2005; O'Brien, 1987; Wiley & Myers, 2003; Zabrucky & Ratner, 1986). Of these factors, the last one –textual distance- has been shown to vary as a function of developmental and individual differences: Younger and struggling readers are less likely than older and proficient readers to detect coherence breaks when contradictory pieces of information are separated from each other in the text, whereas these differences between age and skill groups do not appear when contradictory information is presented in adjacent sentences (Long & Chong, 2001; Oakhill et al., 2005; van der Schoot et al., 2012; Zabrucky & Ratner, 1986; 1989, but cf. Barth et al., 2015). However, it remains unclear whether these findings also apply to a situation in which the number of filler sentences between contradictory information varies. In the current study, we examine the availability of information by varying the textual distance, i.e. the number of filler sentences between pieces of contradictory information. We expect that when the textual distance between context and target information is larger, the

likelihood that the context information is available to a reader and, thus, that the break in coherence is detected decreases.

A frequently used method to investigate whether readers monitor the coherence of texts involves examining whether they detect coherence breaks during reading of short narratives (Albrecht & O'Brien, 1993; Helder et al., 2016; Kendeou et al., 2013; O'Brien & Albrecht, 1992; O'Brien, Rizzella, Albrecht, & Halleran, 1998; van der Schoot et al., 2012; Zabrucky & Ratner, 1986). Reading times are compared between target sentences in incoherent narratives and target sentences in coherent narratives. A classic example is the narrative about Mary (Albrecht & O'Brien, 1993; O'Brien & Albrecht, 1992). In the incoherent version she is introduced as a vegetarian whereas in the coherent version she is introduced as a junk food lover. In both versions Mary orders a cheeseburger in the target sentence presented later in the text. Readers typically show an inconsistency effect: Reading times for target sentences in incoherent narratives (e.g., Mary is a vegetarian) are longer than reading times for target sentences in coherent narratives (e.g., Mary is a junk food lover). This difference in reading times reflects that the contradictory pieces of information (ordering a cheeseburger and Mary being a vegetarian) are both available to the reader during reading and indicates that the coherence break is detected.

This study investigates possible developmental differences in coherence-monitoring processes between younger and older adolescents and, more specifically, the potential influence of textual distance on processes related to coherence-break detection during reading of narrative texts. Based on previous studies that showed that coherence-monitoring processes develop at least until early to middle adolescence (e.g., Bohn-Gettler et al., 2011; Hacker, 1997; Zabrucky & Ratner, 1986), that cognitive-control processes continue to develop throughout adolescence (Huizinga et al., 2006; Luna et al., 2004), and that the availability of information is influenced by the textual distance of the to-be-connected information from the text (e.g., Long & Chong, 2001; O'Brien, 1987; Zabrucky & Ratner, 1986), two contrasting hypothetical scenarios can be derived. If coherence-monitoring processes continue to develop during the second half of adolescence, one would expect younger and older adolescents to show similar patterns of results. In particular, in this scenario one would expect that the likelihood that coherence breaks are detected decreases as a function of textual distance for both younger and older adolescents. If, in contrast, coherence-monitoring processes mature during early adolescence, then one would expect younger and older adolescents to show different patterns of results. In particular, in this scenario one would expect that the likelihood that coherence breaks are detected decreases as a function of textual distance for younger but not for older adolescents.

3.2 Methods

3.2.1 Participants

Eighty-six adolescents participated in this study. To examine developmental differences during adolescence, we recruited participants in two age groups; 46 younger adolescents (aged 10-14 years; 27 female; M_{age} = 11.50, SD_{age} = 1.70) and 40 older adolescents (aged 16-22 years; 27 female; M_{age} = 18.51, SD_{age} = 1.62). All participants have Dutch as their native language and were recruited from elementary and secondary schools or from the University's Social Sciences department. None of the participants had a diagnosis of dyslexia, ADHD, other neuropsychological disorders, or learning difficulties.

3.2.2 Materials

Contradiction paradigm
The experiment consisted of 32 short narratives with a length of seven to ten sentences. A coherent and an incoherent version of each narrative was constructed, based on the contradiction paradigm by O'Brien and colleagues (e.g., O'Brien & Albrecht, 1992; O'Brien et al., 1998). The materials were adapted from Helder et al. (2016) by varying the number of filler sentences to manipulate the textual distance. Each narrative consisted of an introductory first sentence, a second sentence that described a characteristic of a protagonist or a situation, a filler section, followed by a target sentence, and a closing sentence. Each participant read 16 narratives in the coherent version and 16 narratives in the incoherent version. Narratives were presented with a filler section of three, four, five, or six sentences. Thus, the experimental task consisted of 2 (narrative coherence) x 4 (textual distance) conditions, which resulted in four narratives in each condition. In an incoherent narrative, information in the target sentence semantically contradicted information presented in the second sentence, whereas information in the same target sentence in a coherent version did not. For an example narrative see the Appendix. The contradictions were used in a previous behavioral study (Helder et al., 2016) in which children at age 8-9 and 10-11 were explicitly asked whether each narrative made sense or not. The average percentage accurate coherence judgments by good comprehenders was 88.17%. Thus, children in elementary schools were able to detect the coherence breaks. Based on the children's data, it can be expected that younger and older adolescents are able to detect the coherence breaks in the experimental narratives as well.

Participants were presented with one of two sets of materials, with each narrative appearing in coherent version in one set, and in the incoherent version in the other set. Within each set, there was a further constraint in that within each set

narrative (in)coherence would not occur more than three times consecutively. The order of the narratives as well as the number of filler sentences were the same in both sets of materials. The two sets were equally distributed in each age group.

The narratives were presented sentence-by-sentence in black letters (Century Gothic; font size 24) against a grey background on a 15.6 inch laptop screen. Participants were instructed to read at their own pace for comprehension and to press the space bar to continue to the next sentence. Reading times for each sentence was recorded. Following each narrative participants had to answer a yes/no comprehension question (by using the 'S' button for yes and the 'L' button for no). Thus, participants thought their main task was to answer the comprehension questions. A fixation cross was presented for 500 ms between sentences to prevent children from pressing the space bar too rapidly. In addition, participants were not able to continue to the next sentence within 500 ms and if participants did not respond within 10 seconds, the next sentence automatically appeared on the screen.

For each target sentence the reading time was divided by the number of syllables to correct for sentence length. The number of syllables in target sentences ranged from 10-20 ($M = 14.78$, $SD = 2.76$). Participants' target-sentence reading times per syllable for coherent and incoherent narratives were compared and used as a measure of coherence monitoring during reading.

Reasoning ability

Reasoning ability was assessed using Raven's Standard Progressive Matrices (SPM) (Raven, Raven, & Court, 1998). Raven's SPM consists of 60 items, categorized in five sets (A through E) of 12 items each. Each item consisted of a figure from which one part is missing. It is the participants' task to find the missing part out of six or eight options. Participants had 30 minutes to complete the test.

Based on the number of correct items, estimated IQ scores were obtained using international norms (Raven, Raven, & Court, 1998). All participants had average or above average estimated IQ scores and estimated IQ scores did not differ between the younger ($M = 111.67$, $SE = 1.78$), and older adolescents ($M = 107.88$, $SE = 1.91$), $F(1, 84) = 2.12$, $p = .149$, $\eta_p^2 = .03$.

3.2.3 Procedure

All participants were tested individually at their school (participants aged 10-17) or at the university (participants aged 19-22). For the youngest participants, aged 10 or 11, informed consent was given by their parents before the testing session. For the older participants (ages 12 through 22), informed consent was signed at the beginning of the testing session. First, the contradiction paradigm was administered. All participants were

instructed to read short narratives for comprehension and answer a content question after each narrative. They were explicitly asked to read at their own pace, not faster or slower and that they had to keep their fingers on the buttons during reading. Before starting the experimental task, participants received two coherent practice narratives on the computer to familiarize them with the task procedure. Care was taken that each participant understood the task after practice before continuing to the experimental task. The 32 narratives of the experimental task were presented in three blocks, with short breaks after 12 and 22 narratives, respectively. For each participant, the experimental task took approximately 30 minutes to complete. After completion of the experimental task, the Raven's SPM was administered. In addition, for each age group a different set of other reading-related tasks were administered, which will not be further discussed. This makes the total duration of each individual session approximately 75 minutes.

3.3 Results

To ensure that participants followed the instructions and read the narratives for comprehension, we computed the percentage of correctly answered comprehension questions for each participant. An univariate ANOVA on these accuracy data showed that participants' accuracy was high ($M = 94.82$ %, $SE = .51$) and did not differ between younger ($M = 95.11$ %, $SE = .69$) and older adolescents ($M = 94.53$ %, $SE = .74$), $F(1,84) = .33$, $p = .569$. Trials for which reading times were not measured (narratives with sentence reading times of 10 sec or longer) were removed before the analyses (0.01% of the overall data).

3.3.1 Coherence-break detection

To check whether participants were able to detect coherence breaks during reading, participants' mean log-transformed target-sentence reading times were analyzed using a Repeated Measures ANOVA with narrative coherence (coherent vs. incoherent) and textual distance (three vs. four vs. five vs. six filler sentences) as within-subjects factors and age group (younger vs. older adolescents) as a between-subject factor. There was a significant main effect of age group, $F(1,84) = 16.20$, $p < .001$, $\eta_p^2 = .16$, with younger adolescents ($M = 182.34$, $SE = 6.46$) reading more slowly than older adolescents ($M = 145.08$, $SE = 6.93$). There also was a significant main effect of narrative coherence, $F(1,84) = 63.78$, $p < .001$, $\eta_p^2 = .43$, with longer reading times for incoherent target sentences ($M = 171.85$, $SE = 5.05$) than for coherent target sentences ($M = 155.57$, $SE = 4.67$). There was no significant interaction of narrative coherence and age group ($p = .998$). Thus, both younger and older adolescents detected coherence breaks during reading. The significant main effects were qualified by a narrative coherence by textual distance two-

way interaction, $F(3,252) = 3.78$, $p = .011$, $\eta_p^2 = .043$, which was further qualified by a narrative coherence by textual distance by age group three-way interaction, $F(3,252) = 2.89$, $p = .036$, $\eta_p^2 = .03$.

3.3.2 Comparing younger and older adolescents

To investigate whether there are developmental differences between younger and older adolescents, we followed-up on the three-way interaction by analyzing the effect of textual distance on coherence-break detection for the younger and older adolescents separately. To do so, participants' mean log-transformed target-sentence reading times were converted into difference scores: for each participant, the average log-transformed reading time on target sentences in coherent narratives was subtracted from the average log-transformed reading time on target sentences in incoherent narratives. These difference scores reflect the inconsistency effect: the greater the difference score, the more the reader engages in additional cognitive processes in incoherent narratives compared to coherent narratives. Mean difference scores for each of the textual distance conditions for younger and older adolescents are displayed in Figure 3.1.
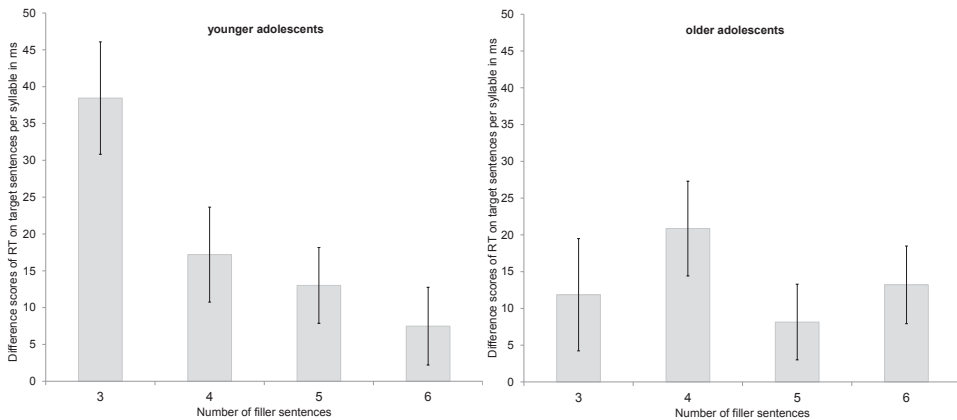

Figure 3.1. Mean difference scores (participant's reading times for incoherent target sentences – reading times for coherent target sentences) and Standard Errors for younger and older adolescents. There is a significant linear decrease of the inconsistency effect in younger adolescents but not in older adolescents.

Participants' difference scores were analyzed using a Repeated Measures ANOVA with textual distance (three vs. four vs. five vs. six filler sentences) as within-subjects factor. In younger adolescents there was a significant main effect of textual distance, $F(3,135) = 5.80$, $p = .001$, $\eta_p^2 = .11$; within-subject contrasts revealed a linear trend, $F(1,45) = 14.21$,

$p < .001$, $\eta_p^2 = .24$, with difference scores decreasing when textual distance increased. For older adolescents, there was no significant main effect of textual distance, $F(3, 117) = 1.52$, $p = .214$, $\eta_p^2 = .04$; within-subject contrasts did not reveal a linear trend, $F(1, 39) = .86$, $p = .360$, $\eta_p^2 = .02$.

3.3.3 Additional analyses within age groups

Because the age range within both age groups is relatively large and collapses across different school contexts, we conducted analyses to gain insight into possible differences within each age group. However, these analyses should be interpreted with caution because sample sizes are relatively small. Within the younger adolescents group, we analyzed the difference scores of the younger (*elementary school*, aged 10-11; $N = 30$; 18 female; $M_{age} = 10.43$, $SD_{age} = .35$) and the older participants (*middle school*, aged 13-14; $N = 15$; 9 female; $M_{age} = 13.84$, $SD_{age} = .94$) separately. Both groups showed the same pattern of results as reported above; elementary-school students ($F(3,90) = 3.13$, $p = .029$, $\eta_p^2 = .10$) and middle-school students ($F(3,42) = 2.99$, $p = .042$, $\eta_p^2 = .18$) showed a significant main effect of textual distance; within-subjects contrasts revealed a linear trend ($F(1,30) = 7.39$, $p = .011$, $\eta_p^2 = .20$, and $F(1,14) = 7.28$, $p = .017$, $\eta_p^2 = .34$, respectively), with difference scores decreasing when textual distance increased. Likewise, within the older adolescents group, we analyzed the difference scores of the younger (*high school*, aged 16-17; $N = 14$; 6 female; $M_{age} = 17.18$, $SD_{age} = .54$) and the older participants (*university*, aged 19-22; $N = 26$; 21 female; $M_{age} = 20.02$, $SD_{age} = 1.00$) separately. Both groups showed the same pattern of results as reported above; high-school students ($p = .550$) and university students ($p = .114$) showed no significant main effect of textual distance; within-subjects contrast did not revealed a linear trend ($p = .397$ and $p = .510$, respectively).

3.4 Discussion

The aim of this study was to examine possible developmental differences in coherence-monitoring processes between younger (ages 10-14) and older (ages 16-22) adolescents and more specifically, the potential influence of textual distance on processes related to coherence-break detection during reading of narrative texts. Results show that adolescents' reading times are longer for target sentences in incoherent narratives than in coherent narratives. Thus, adolescents in both age groups are able to detect coherence breaks during reading of narratives, consistent with the results from previous studies that have used variations of the contradiction paradigm with children (e.g., Helder et al., 2016; van der Schoot et al., 2012; Zabrucky & Ratner, 1986), early adolescents (e.g., Bohn-Gettler et al., 2011; Hacker, 1997), and adults (Albrecht & O'Brien, 1993; O'Brien et al., 1998).

In younger adolescents, the likelihood that prior context information is available when reading target information and, thus, that a coherence break is detected, decreases when textual distance increases. This pattern was not observed in older adolescents. Thus, textual distance seems to affect younger adolescents more than older adolescents. This suggest that coherence-monitoring processes, such as those related to coherence-break detection, are still developing during the first half of adolescence and, in the context of this specific experimental task, are relatively mature in the second half of adolescence.

The developmental differences in sensitivity to textual distance resemble patterns of sensitivity to textual distance as a function of individual differences in reading comprehension ability observed in earlier research. For example, textual distance seems to influence coherence-monitoring processes more in poor comprehenders than in good comprehenders, in both elementary-school children (Oakhill et al., 2005; van der Schoot et al., 2012; Zabrucky & Ratner 1989) and adults (Long & Chong, 2001). One explanation for this difference between good and poor comprehenders refers to the general finding that in good comprehenders cognitive-control processes, such as working memory, function more effectively than in poor comprehenders (e.g., Cain, Oakhill, & Bryant, 2004; Just & Carpenter, 1992; Locascio, Mahone, Eason, & Cutting, 2010; Swanson & Berninger, 1995, but see Van Dyke & Schankweiler, 2013). For instance, in the context of the reading comprehension literature working memory refers to the reader's capacity to process information in the text and to update the evolving mental representation during reading (Conway et al., 2005; Daneman & Carpenter, 1980; Linderholm & van den Broek, 2002). The more working-memory capacity is available during reading, the more likely it is that information separated in the text is activated simultaneously (e.g., Kintsch & Van Dijk, 1978; van den Broek & Kendeou, 2008; van den Broek, Rapp, & Kendeou, 2005) and, consequently, that potential breaks in coherence are detected. The same logic may apply to our developmental findings; older adolescents may be less affected by the increase in textual distance than younger adolescents because their working-memory capacity and other cognitive-control related processes are more mature (Huizinga et al., 2006; Luna et al., 2004). However, it is conceivable that under more challenging circumstances, such as a further increases in textual distance or the use of more complex texts, even the older adolescents' working-memory capacity is exceeded and may affect their coherence-monitoring processes as well.

In the current study, the textual distance between contradictory pieces of information varied from three to six sentences. At longer distances, such as in texts in school, other factors that influence the availability of information may become more important. For example, the amount of elaboration on the context information (Kendeou et al., 2013; O'Brien et al., 1998) or the degree to which the to-be connected information is relevant for the causal structure of the text (O'Brien & Myers, 1987; Trabasso & van den Broek,

1985; van den Broek, Helder, & Van Leijenhorst, 2013) have been shown to influence the availability of information of the text in working memory by making the trace of the concept in the memory representation stronger. The stronger the activation of a concept, the more likely this concept is integrated in a reader's mental representation of the text (e.g., Cook & O'Brien, 2014; van den Broek, Risden, Fletcher, & Thurlow, 1996). However, the majority of studies to date have examined these coherence-building processes in children or adults, and relatively little is known about adolescence. The literature on the continued development of cognitive-control processes during the second half of adolescence, together with the increased demands on adolescents' coherence-monitoring ability point to the importance of investigating these factors in an adolescent population and, more specifically, in the second half of adolescence, to fully understand the development of processes related to coherence monitoring, an essential component of reading comprehension.

The present findings raise the question of what the underlying mechanisms of a decrease of the inconsistency effect as a function of textual distance are. Although the method used in the present study does not allow to providing a definite answer, there are several conceivable scenarios that may have implications for the interpretation of the inconsistency effect. One possibility is that the decrease of the inconsistency effect is a reflection of gradation of coherence-break detection between readers. For example, more readers could be able to detect coherence breaks when the incoherent information is separated by three filler sentences, fewer readers by four, even fewer by five etc. Aggregated across individuals, the net effect would be a decrease in the strength of the inconsistency effect. In that case, one would expect that the variances in the difference-score data are smaller in conditions in which the textual distance between incoherent pieces of information is relatively small (three filler sentences) or large (six sentences) compared to the intermediate textual distance conditions (four and five filler sentences). We did not find such a pattern in our data. Another possibility is that the decrease of the inconsistency effect is a reflection of a gradation of coherence-break detection within a reader. For example, it could be that the degree of availability of context information and, as a consequence, the likelihood that a coherence break is detected, gradually decreases for each reader as the textual distance increases (for a similar discussion in the domain of working memory see Ma, Husain, & Bays, 2014). The current study does not allow us draw firm conclusions about which of these scenarios, or any other, is most likely to explain the textual-distance effect. Other methods, such as probing measures, could provide additional information about the extent to which context information is available to a reader when coherence is disrupted.

To conclude, this study contributes to the existing literature on the development of coherence-monitoring processes by showing that the processes related to the detection

of coherence breaks during reading continue to develop in the first half of adolescents and seem to be relatively mature in the second half of adolescence. With age, texts in school become longer and more complex and, as a consequence, students' ability to monitor the coherence of their mental representation of texts becomes more important as well. Although the results of the present study could be taken to suggest that older adolescents perform at an adult level, we are hesitant to draw this conclusion. Rather, we would like to point out that, to understand the development of coherence-monitoring processes completely, future studies should include investigation of such processes in the second half of adolescence. Central questions of future studies should include the influence of individual factors, such as working memory, as well as of factors that affect the availability of information on students' coherence-break detection processes, an essential component of successful reading comprehension.

Appendix

Example of narrative presented sentence-by-sentence in the contradiction paradigm in a coherent and incoherent version (adapted from Albrecht & O'Brien, 1993). Textual distance is manipulated by varying the number of filler sentences.

Introduction
Oscar and Ruben are ten-year-old twins who do almost everything together.

Coherent version
Because there has been a lot of snow in the past few days, they don't have to go to school today.

Incoherent version
Because the weather has been very hot in the past few days, they don't have to go to school today.

Filler section (varies between 3, 4, 5, or 6 filler sentences)
Their mother works for a large company and is working from home today.
Today she is very busy with her work, she has to finish a report.
Oscar and Ruben are playing outside so they do not disturb her.

Target sentence
They are building a snowman in the backyard.

Final sentence
They are happy to have a day off.

Comprehension Question
Are Oscar and Ruben of the same age? Yes / No