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The influence of connectives on young readers' processing and comprehension of text

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Abstract

Connectives are cohesive devices that signal the relations between clauses and are critical to the construction of a coherent representation of a text's meaning. We investigated young readers' knowledge, processing, and comprehension of temporal, causal, and adversative connectives using off-line and on-line tasks. In a cloze task, 10-year-olds were more accurate than 8-year-olds on temporal and adversative connectives, but both age groups differed from adult levels of performance (Experiment 1). When required to rate the 'sense' of two-clause sentences linked by connectives, 10-year-olds and adults were better at discriminating between clauses linked by appropriate and inappropriate connectives than were 8-year-olds. The 10-year-olds differed from adults only on the temporal connectives (Experiment 2). In contrast, on-line reading time measures indicated that 8-year-olds' processing of text is influenced by connectives as they read, in much the same way as 10-year-olds'. Both age groups read text more quickly when target two-clause sentences were linked by an appropriate connective compared to texts in which a connective was neutral (*and*), inappropriate to the meaning conveyed by the two clauses, or not present (Experiments 3 and 4). These findings indicate that although knowledge and comprehension of connectives is still developing in young readers, connectives aid text processing in typically developing readers.

Keywords: children, connectives, reading comprehension, text processing

The influence of connectives on young readers'

processing and comprehension of text

The product of successful reading comprehension is a coherent representation of the text's meaning, referred to as a situation model (Kintsch, 1998) or mental model (Johnson-Laird, 1980). In order to establish coherence, the reader must relate different events in the text, a process regarded as the "the cornerstone of comprehension" (Graesser, McNamara, & Louwerse, 2003). Connectives (or conjunctions - Halliday & Hasan, 1976) are cohesive devices, such as *because*, *but*, and *after*, that can aid this process for skilled readers by signaling the nature of the relation between events (Costermans & Fayol, 1997; Degand & Sanders, 2002; Sanders & Noordman, 2000). We report four experiments that investigated the influence of connectives on young readers' processing and understanding of text, to determine whether connectives help or hinder young readers to establish coherence when reading.

Different groups of connectives signal specific types of coherence relation between events and therefore convey different instructions about how to integrate this information (Gernsbacher, 1997). Temporal connectives such as *before* and *after* indicate the sequence of events in time: consider the different meanings and implications of 'Chris left the barbecue before/after it started to rain'. Causal connectives such as *because* or *so* signal cause-effect relations and help readers to understand why things occurred: compare 'Charlie was late for work because/so he took the bus.' Adversative connectives such as *but* and *although* are used to provide information that is contrary to expectations, as shown by: 'The engagement ring was expensive but/although the diamond was small'.

Skilled adult readers readily use the information provided by connectives

when reading. The presence of an appropriate connective between two clauses leads to faster reading times, better memory, higher ratings of textual coherence, and facilitates inference making when the relation between events is not explicitly stated (Caron, Micko, & Thuring, 1988; Ferstl & von Cramon, 2001; Millis, Golding, & Barker, 1995; Murray, 1997). Furthermore, adult readers use this information soon after reading the connective (Traxler, Bybee, & Pickering, 1997). Given that connectives benefit skilled readers, the expectation is that they will also be helpful to developing readers, provided they understand their meanings.

The age at which young readers successfully comprehend and interpret connectives is particularly relevant to the recently introduced Common Core State Standards for reading, adopted by several states in the USA (CCGSI & NGA, 2010). Within this framework, the ability to read and understand complex texts independently is considered crucial for college and career readiness. To develop the necessary skills for this, it is essential that children are able to read and understand texts of increasing complexity as they progress through school. To ensure that readers are given materials of suitable complexity for their ability or grade level, and also that readers' ability is accurately estimated by reading comprehension tests, appropriate measures of text complexity are critical.

Text complexity can be assessed with readability formulae, such as Flesch-Kincaid Grade Level, Dale-Chall Readability Formula, and the Lexile system. These typically use word length or frequency and sentence length as proxies for semantic and syntactic complexity, to calculate the difficulty level of a given text. According to these formulae, a text with sentences that include clauses linked by connectives will be rated as more difficult to read than one in which the connectives are removed and the clauses presented as single sentences without explicit links between each clause.

This method of computing text complexity may be appropriate if young readers are not able to interpret the information provided by connectives, but it will not be appropriate if young readers benefit from the presence of connectives and are able to use them to guide their comprehension. Indeed, a different approach to text readability is adopted by the Coh-Metrix system, which rates the cohesiveness of a text (Graesser, McNamara, Louwerse, & Cai, 2004). A highly cohesive text signals the relations between words, sentences, and ideas through devices such as repetition and connectives. It is clear that we need to know the age at which young readers benefit from connectives (as well as other cohesive devices) to develop appropriate measures of text complexity.

The majority of developmental studies have focused on production, rather than comprehension, of connectives. Children produce a range of connectives by about 5 years of age (Kail & Weissenborn, 1991; Spooren & Sanders, 2008). Acquisition of these connectives follows a developmental pattern. Connectives to express additive relations, such as *and*, are generally acquired first, followed by connectives to express temporal, causal, and finally adversative relations (Bloom, Lahey, Hood, Lifter, & Fiess, 1980). The order of acquisition is related to the cognitive complexity of the specific coherence relation, guided by parameters such as polarity and the strength of the relation, e.g., additive vs causal (Evers-Vermeul & Sanders, 2009; Spooren & Sanders, 2008).

The early appearance of connectives in speech suggests that young readers will benefit from connectives. However, appropriate use of connectives (Peterson, 1986) and indeed understanding of them (Irwin & Pulver, 1984) continues to develop for several years after they first appear in children's speech. Even some adult readers fail to appreciate the more sophisticated focus rules associated with *but* and *although*

(McClure & Geva, 1983).

Most studies of children's comprehension of connectives have examined whether or not the presence of a connective in general aids understanding (e.g., (Bridge & Winograd, 1982; Geva & Ryan, 1985). Where performance between connectives that signal different types of coherence relations has been compared, differences are evident. Using a cloze procedure, Cain, Patson and Andrews (2005) found that 10-year-olds were more likely than 8-year-olds to choose the correct connective to signal temporal, causal, and adversative coherence relations, but they found no age differences for additive relations. Similarly, in a study of 9-year-old English language learners, Crosson, Lesaux, and Martiniello (2008) found that performance for temporal, causal, and adversative relations was poorer than for additive ones.

The data from off-line comprehension tasks indicate that knowledge of connectives is still developing in young readers. This supports the notion that the presence of connectives in text does not necessarily help understanding and that a text rated as cohesive will not necessarily be better understood by young readers than one that is less cohesive. In contrast, data from a reading time study of connectives indicates that from eight years of age, children benefit from connectives and read a segment of text more quickly when it is preceded by a connective relative to no connective present (Mouchon, Fayol, & Gaonac'h, 1995). That study investigated just two connectives, *mais* (but) and *soudain* (suddenly), so it remains to be seen whether children process and benefit from a range of connectives that signal different types of coherence relation, as they are reading.

If it is indeed the case that young readers do not benefit from connectives, it may be for different reasons. They may not fully understand the relation signaled by a

particular connective. The data from off-line cloze tasks supports this interpretation, although these studies are limited by the small numbers of items used to assess comprehension of each connective (e.g., Cain et al., 2005; Crosson et al., 2008). An alternative explanation is that young readers are knowledgeable about the meanings of different connectives but fail to benefit because they do not always attend to them. In support of this, an off-line comprehension study found that children who were poor readers benefitted from the inclusion of connectives only when they were highlighted in the text (Geva & Ryan, 1985).

As noted, connectives play a central role in theories of skilled text processing and are an important indicator of text cohesiveness. To date, we do not know the extent to which connectives influence reading comprehension in school-age children and, therefore, how their presence should be weighted when computing a text's complexity. Indeed, the nature of the task may influence whether or not young readers are found to benefit from connectives. A more detailed understanding of connective processing and comprehension is needed to further our understanding of the development of reading comprehension more generally, and to design curricula so that instruction and materials are suitable for the skills and knowledge of that age group.

The current research

Our research was designed to address the main question: Do connectives help or hinder young readers? Specifically, we addressed three research questions. Do young readers understand the different types of coherence relations expressed by different connectives? Does the presence of an appropriate connective help children to establish the coherence relations between events? Do connectives have an impact as the child is reading or does the impact occur later? These research questions were

addressed by investigating developmental patterns in young readers' performance on tasks that assessed the processing and comprehension of sentence pairs and short texts containing connectives that specified temporal, causal, and adversative coherence relations. We compared 10- and 8-year-olds because these age groups have been found to differ in connective competence in previous research (Cain et al., 2005). On-line tasks measure processing as it occurs in real time, whereas off-line tasks measure the product of this processing. We report four experiments using both types of measure to provide a comprehensive picture of competence.

Experiment 1

The aim of Experiment 1 was to determine whether or not young readers show the same knowledge of the meaning conveyed by different types of connectives as adults. This work extended that of Cain et al. (2005) who embedded cloze sentences in extended text (passages of 779 and 836 words in length). Here we used a sentence cloze task that had relatively low memory and processing demands. If young readers' knowledge of particular connectives is still developing, they will be less likely to select the appropriate connective to link two short sentences compared to skilled adult readers. If differences follow the same pattern as those reported in production research, performance should be poorest for adversative connectives.

Method

Participants. Three groups participated: 17 undergraduate and postgraduate university students (aged between 20 and 39 years, 4 males, 13 females), 50 children in Year 5 (UK Primary school, 30 boys, 20 girls) aged 9-10 years (hereafter 10-year-olds), and 46 children in Year 3 (17 boys, 29 girls) aged 7-8 years (hereafter 8-year-olds). All were native speakers of British English. Adults were paid for their

participation. Their performance was close to ceiling and is reported to demonstrate levels of performance by skilled readers.

For this and all other work reported in this paper, the procedures received ethical approval from the departmental ethics committee, in line with the guidelines of the British Psychological Society. Written consent was obtained from schools and parents for the children and from the individual adult participants. Children gave oral consent for each session. Different children and adults participated in the different experiments reported in this paper.

Materials. Seventy-two sentences written with vocabulary suitable for children in the youngest age group were constructed. Each sentence comprised two clauses written to convey a coherent semantic relation. The target connectives that joined the two clauses were selected to signal different coherence relations: temporal (*before, after*), causal (*so, because*), and adversative (*but, although*), with 12 sentences for each. These connectives were selected because they have been used in previous work with young readers (Johnston & Welsh, 2000; Stevenson & Pollitt, 1987). The first clause of the sentence always contained a noun (subject), a verb, and a second noun (object). For each of the six connectives, there were six sentences in which the second clause referred to the subject of the first clause and six in which it referred to the object. The mean length of the sentence was 10.46 words and second clauses that referred to objects were shorter than those that referred to subjects (3.31 vs 4.11 words). Examples are provided in the Appendix.

Three connectives served as the choices to complete the blank in each sentence: the appropriate connective, an inappropriately placed connective (a connective that indicated a different relation to the one conveyed by the sentence pair), and the additive connective *and*. The materials were piloted first with 24 adult

native English speakers. The mean number of correct selections was 11.47 (out of 12). Five items were identified as problematic and modified to make the target connective more acceptable and the nontarget connective less acceptable in the judgment of the authors. Cronbach's alpha for the final set of items confirmed adequate internal consistency for the three types of coherence relations: $\alpha_s = .79$, $.78$, and $.87$ for temporal, causal, and adversative, respectively.

Procedure. Three lists were created, each presented the options for a given item in a different order (first, second, or third). The item order was pseudo-randomised to create two versions of each list. Adults were tested in small groups in a quiet room and completed the task in one session lasting approximately 15 minutes. Children completed the task in two separate sessions in a quiet room within their school. The task was presented in a booklet and children were instructed to: "*Read each sentence carefully and then choose the word that best fills the gap.*" The experimenter went through some examples with participants before they completed the experimental items on their own.

Results

The proportions of correct target selections are reported in Table 1. For temporal and adversative connectives there were clear differences in performance between the three age groups: adults > 10-year-olds > 8-year-olds. For the causal connectives, adults obtained the highest scores, but the 10-year-olds obtained similar scores to the 8-year-olds (80% and 78% correct, respectively).

The data for the proportion correct responses were arcsin transformed before a mixed analysis of variance was performed, in which age group (10 years, 8 years) was a between-subjects factor and type of coherence relation (temporal, causal, adversative) was a within-subjects factor. Two analyses were conducted. In one,

participants were treated as a random factor and in the other, items were treated as a random factor. We report η^2_p (the proportion of the effect and error variance that is attributable to the effect) as the measure of effect size for all significant effects and interactions. Throughout this paper, significant interactions were explored with simple main effects analysis and posthoc Tukey comparisons ($\alpha = .05$), as recommended by Roberts and Russo (1999).

TABLE 1 AROUND HERE

In general, the 10-year-olds were more accurate than the 8-year-olds ($F_1(1, 94) = 7.91, p < .01, \eta^2_p = .08$; $F_2(1, 69) = 6.32, p < .01, \eta^2_p = .16$) and accuracy was higher for temporal and adversative connectives than for causal connectives ($F_1(2, 188) = 8.75, p < .001, \eta^2_p = .09$; not significant by items, $F_2(1, 69) < 1.0, ns$). There was a significant interaction between age and type of coherence relation ($F_1(2, 188) = 5.71, p < .01, \eta^2_p = .06$; $F_2(2, 69) = 56.69, p < .01, \eta^2_p = .45$). Simple effects analysis revealed significantly more accurate performance by the 10-year-olds for temporal and adversative connectives (all $F_s > 7.50, p_s < .01$), but no difference between the two age groups for causal connectives ($F_s < 1.0$). Looking at performance within each age group, accuracy was comparable for each type of coherence relation ($F_s < 1.0$).

The majority of non-target responses involved the selection of *and*. The total proportions of *and* selections were temporal = .62; causal = .76; adversative = .68, collapsed over age group. These data are based on different number of responses for each connective, different choices of nontarget connective, and often very small numbers. Thus, further analysis was not considered informative.

Discussion

Performance on the cloze task was high, demonstrating that young readers are often able to select the appropriate connective to link two coherent clauses when processing

demands are minimal and they have time to reflect on the correct selection of a connective in the context of a single sentence. In general, the older children were more likely to select the correct connective than younger children and these differences were significant for temporal and adversative connectives. This finding suggests that 10-year-olds have a better understanding of these connectives than 8-year-olds.

Performance for causal connectives was, in general, poorer than performance for adversative connectives. This pattern of data is different to that found in production studies (but it supports Cain et al.'s (2005) finding of relatively good performance for adversative connectives). Analysis of errors indicated a strong preference for the selection of *and*, which is a general or less-specific connective that can be used to express temporal, causal and adversative relations, as well as additive ones (Knott & Sanders, 1998; Peterson & McCabe, 1987). Because *and* matches the temporal order of events when the target link is *so*, it is an appropriate choice, which may have led to an underestimation of actual competence for causal connectives for all age groups. In contrast, the inclusion of *and* may have overestimated performance on adversative connectives because it is a less appropriate alternative. Analyses of children's speech shows that *and* is used less frequently to express adversative than temporal and causal relations (Peterson & McCabe, 1987). Both groups of children were more likely than the adults to select *and*, suggesting that they have a poorer knowledge of the information provided by the specific connectives.

Experiment 2

Adults perceive a sentence following an inappropriately placed connective as a less sensible or coherent continuation relative to one following an appropriate connective (Murray, 1997). We used a similar procedure to determine whether the presence of an

inappropriately placed connective affected young readers' sense of coherence using a sense rating task. Sense judgment paradigms have been used with both typically and atypically developing readers in this age range in previous reading comprehension research (Baker, 1984; Barnes, Faulkner, Wilkinson, & Dennis, 2004; Oakhill, Hartt, & Samols, 2005).

Method

Participants. Three groups participated: 20 undergraduate and postgraduate students (10 males and 10 females), 60 10-year-olds (21 boys, 39 girls), and 64 8-year-olds (24 boys, 42 girls). All were native speakers of British English. The adults were paid for their participation.

Materials and design. The materials were the same seventy-two sentences used in Experiment 1. Two versions of each sentence were constructed. In one, the two clauses were linked by an appropriate connective and, in the other, the connective was inappropriate according to the judgments of adults in pilot work. Two lists were created, each with 72 sentences comprising 36 appropriate items (12 for each coherence relation) and 36 inappropriate items (12 for each coherence relation). See Appendix for examples. Each participant completed only one list.

The task was presented in a booklet. By each item, there was a rating scale of 5 empty circles. Underneath each circle was a label: 'yes', 'a bit', 'not sure', 'not really', and 'no'. The instructions were printed on the first page and read out to children: *"Read each sentence carefully and then ask yourself 'Does this sentence make sense'? If it definitely does make sense, tick 'yes'. If it makes a bit of sense tick 'a bit'. If you are not sure whether it makes sense or not tick 'not sure'. If it does not really make sense tick 'not really'. If it definitely does not make sense tick 'no'."*

The instructions were modified slightly for adults. The children worked through four

examples with the experimenter, with one example fitting each rating except 'not sure'. In the children's booklets the question was restated at the top of each page. Children were tested in their classroom as a group and completed the work in two sessions. Adults were tested in small groups and completed the work in a single session.

Results

Each age group awarded higher ratings in the appropriate than in the inappropriate condition (mean sense ratings in Table 2). In addition, the adults awarded the highest ratings in the appropriate condition, followed by the 10-year-olds and then the 8-year-olds. We explored the accuracy of responses by calculating d' , to measure the ability to discriminate between appropriate and inappropriately placed connectives, and estimated response bias (i.e., willingness to say 'yes') by calculating the criterion c . To do this, we first created a 2 (appropriate, inappropriate) x 2 (makes sense, does not make sense) contingency table. No participants used the 'definitely does not make sense' ratings so the ratings were clustered with 1 (yes definitely) and 2 (a bit) grouped as 'makes sense' and 3 (not sure) and 4 (not really) grouped as 'does not make sense'. Using this grouping, the number of hits (appropriate items judged to make sense) and false alarms (inappropriate items judged to make sense) were derived and used to calculate d' and c . The data distributions were within acceptable limits for normality.

TABLE 2 AROUND HERE

FIGURE 1 AROUND HERE

The d' scores are illustrated in Figure 1. A larger value indicates better discrimination between the appropriate and inappropriate items. These scores were treated as the dependent variable in a two-way ANOVA with age group and

coherence relation as factors. In general, the adults and 10-year-olds showed more accurate discrimination between appropriate and inappropriately placed connectives than the 8-year-olds ($F(2, 141) = 13.42, p < .001, \eta^2_p = .16$), and discrimination was strongest for causal coherence relations ($F(2, 282) = 14.76, p < .001, \eta^2_p = .10$). There was also a significant interaction between age group and coherence relation ($F(4, 282) = 6.33, p < .001, \eta^2_p = .08$).

Analysis of the interaction revealed differences between the age groups for each type of coherence relation (all $F_s > 3.40, p_s < .05$). The adults and the 10-year-olds did not differ from each other in their discrimination for any coherence relations (all $p_s > .20$). In contrast, the adults were significantly better than the 8-year-olds at discriminating between appropriate and inappropriately placed connectives ($p_s < .05$) and the 10-year-olds showed better discrimination than the 8-year-olds for causal and adversative connectives ($p_s < .05$), but not for temporal connectives ($p > .40$). In addition to the differences between age groups, each age group differed in their ability to discriminate between the appropriate and inappropriately placed connectives for the three types of coherence relation (all $F_s > 3.75, p_s < .05$). For adults, the d' score for temporal connectives was significantly lower than that obtained for causal connectives. For 10-year-olds, the d' score for temporal connectives was significantly lower than that obtained for both causal and adversative connectives. For the 8-year-olds, there were significant differences between the d' scores in the following order: causal > temporal > adversative ($p_s < .05$).

The criterion scores were analyzed in a two-way ANOVA with age group and type of coherence relation as factors. A larger value indicates that stronger evidence is required before responding that a signal is present (i.e., a higher rate of hits to appropriate connectives and a lower rate of false alarms to inappropriately placed

connectives). The pattern of performance was different to that found in the analysis of d' . The adults ($M=.68$) and 10-year-olds ($M=.73$) obtained higher values than the 8-year-olds ($M=.53$), but the main effect of age group did not reach conventional levels of significance ($F(2, 141) = 2.61, p = .08$). Further, the three types of coherence relations did not differ from each other ($F(2, 282) < 1$). However, there was a significant interaction between group and coherence relation ($F(4, 282) = 3.21, p < .015, \eta^2_p = .04$).

Analysis of the interaction revealed one significant difference between age groups: the 10-year-olds required a higher criterion than the 8-year-olds ($p < .05$) when making decisions about adversative connectives. In addition, there was a tendency for the adults and the 10-year-olds to require stronger evidence than the 8-year-olds before making a decision about causal connectives ($ps = .07$ and $.08$). Separate analyses for each age group revealed that the adults did not set different criterion levels for different types of coherence relations ($F < 1.0$). In contrast, the 10-year-olds required a higher criterion for adversative than for temporal connectives ($Ms = .87$ and $.65$, in order, $p < .05$), and the 8-year-olds required a higher criterion for temporal than for causal connectives, ($Ms = .60$ and $.42$ in order, $p < .05$).

Discussion

Readers as young as 8 years were sensitive to the function of a range of coherence relations, judging clauses linked by an inappropriately placed connective to make less sense than those linked by an appropriate connective. This effect was apparent for the three different types of coherence relation. Thus, similar to adults (e.g., Murray, 1997) young readers interpret different connectives according to the specific type of coherence relation they specify, rather than as a more general linking word.

The d' scores revealed developmental differences in the ability to differentiate appropriate from inappropriately placed connectives. The 10-year-olds performed at a similar level to the adults for causal and adversative connectives. In contrast, the 8-year-olds were poorer than the adults at discriminating appropriate from inappropriate uses of all coherence relations, and were poorer than the 10-year-olds on causal and adversative connectives. For temporal connectives, the performance of the 10-year-olds fell in between that of the 8-year-olds and adults, but the 10-year-olds did not differ from either group. These data indicate that the 10-year-olds' knowledge of connectives is similar to adults', whereas the 8-year-olds' is still developing. Although, in general, there was no evidence for differences between adults and children in their willingness to say yes to particular types of coherence relation, the 10-year-olds adopted a higher threshold for adversative connectives compared with 8-year-olds. In sum, these data suggest that 10-year-olds have reached adult levels of competence for causal and adversative connectives, whereas 8-year-olds' knowledge of these two types of coherence relation lags that of 10-year-olds.

Experiment 3

The first two experiments found differences between 10- and 8-year-olds in their knowledge of connectives that signal different types of coherence relation.

Experiment 3 explored the on-line processing of connectives, to determine whether or not young readers process connectives as they read and whether their sense of the coherence of the text is influenced by the presence of connectives. Children aged 10 and 8 read short texts containing target sentences, which were two-clauses linked either by an appropriate connective, an inappropriately placed connective, or *and*. They judged whether or not the sentence made sense. On the basis of the results of Experiment 2, both age groups should be sensitive to the appropriateness of

connectives in general. Therefore, they should judge more of the texts linked by an appropriate connective to make sense than those linked by an inappropriately placed connective. The effect of link should be qualified by interactions with age group and type of coherence relation because the 10-year-olds were more accurate than the 8-year-olds on causal and adversative connectives in Experiment 2. Finally, if young readers take advantage of the information signaled by a connective as they are reading, reading times should be quickest for texts that include an appropriate connective and slowest for texts that include an inappropriately placed connective.

Method

Participants. Two groups participated: 46 10-year-olds (17 boys, 29 girls) and 46 8-year-olds (29 boys, 17 girls).

Materials and design. Six sentences for each of the six connectives (*before, after, so, because, but, although*) were selected from the original 12 sentences used in Experiment 2. The sentences chosen were those that received the highest sense ratings in that study (when presented in the appropriate condition). Three versions of each sentence were created, which differed only in the linking term: appropriate connective, inappropriately placed connective, or *and*. In order to maintain a balance of the connectives used in the inappropriate condition, five of these items contained a different connective to that used in Experiment 2.

A story frame was written for each target sentence, which consisted of a sentence before, which introduced the subject of the connective sentence, and a sentence after the connective sentence, which referred to the subject and/or object of the connective sentence. An example is provided in the Appendix.

Three lists of materials were created, containing six stories for each of the six connectives: two containing the appropriate connective, two containing an

inappropriately placed connective and two containing *and*. This resulted in 12 items for each type of coherence relation (temporal, causal, adversative). The stories were rotated across condition, across the three lists. Each participant received one of these lists. In addition, 12 filler stories were written, in which the middle (second) sentence contained an element that did not fit with the rest of the story, resulting in 12 additional stories in each list that did not make sense. An example is provided in the Appendix. The same fillers were used for each list.

Procedure. Each child was tested individually in a quiet room. The texts were presented on a laptop computer using E-Prime software (Schneider, Eschmann, & Zuccolotto, 2002). Before the experimental items were administered, participants completed four practice stories, two of which made sense and two that did not. The experimenter modeled the first practice trial. The texts were presented one sentence at a time. After reading the first sentence, participants advanced to each successive sentence using the central button on a response box. After the final sentence, the following text appeared (in red ink): “Did the story make sense?” Participants responded by pressing the yes or no buttons, which were either side of the central response button, with the yes button used for their dominant hand. After the practice items, the instructions were repeated and the 36 test stories were then presented in a random order. Between each trial, there was a ‘pause’ screen, which was advanced by the experimenter (using the computer key board). The reading time for each sentence and the response time and accuracy to the sense question were measured.

Results

One male 8-year-old made ‘yes’ judgments to all texts including the nonsense filler items, so his data were excluded from both analyses.

Analysis of sense judgments. The full set of means by condition is reported in Table 3. Each age group accepted a greater proportion of appropriate items as sensible and was least likely to judge inappropriate items as sensible, for each type of coherence relation. Acceptability for items linked by *and* fell between these two conditions, and was lowest for temporal connectives. The judgment data (raw scores) were within acceptable limits for normality and were treated as the dependent variable in two analyses of variance (in one, subjects were treated as a random variable, in the other, items were treated as a random variable) with the following factors: age (10 years, 8 years), coherence relation (temporal, causal, adversative) and link (appropriate, and, inappropriate).

Not all of the main effects were significant in both analyses. In general, the 10-year-olds accepted slightly fewer texts than the 8-year-olds ($F_1(1, 89) = 1.73, p = .19; F_2(1, 33) = 4.90, p < .05, \eta^2_p = .13$) and texts with a target causal connective (collapsed over link) were more likely to be accepted than those with either target temporal or adversative connectives ($F_1(2, 178) = 19.49, p < .001, \eta^2_p = .18; F_2(2, 33) = 2.33, p = .11, \eta^2_p = .12$). In both analyses, texts linked by an appropriate connective were more likely to be judged to make sense than those linked by either *and* or an inappropriately placed connective ($F_1(2, 178) = 203.48, p < .001, \eta^2_p = .69, F_2(2, 66) = 101.89, p < .001, \eta^2_p = .76$).

Of specific interest was the predicted interaction between coherence relation and link, which was significant ($F_1(4, 356) = 8.87, p < .001, \eta^2_p = .09, F_2(4, 66) = 2.51, p = .050, \eta^2_p = .13$). For each type of coherence relation, texts with an inappropriately placed connective were less likely to be judged as making sense than texts with an appropriate connective or *and* (all $ps < .05$). Texts with an appropriate connective were more likely to be judged as making sense than those linked by *and*

(both $ps < .05$) for the temporal connectives only. When looking at the three types of link (appropriate, inappropriate, *and*), different patterns were evident. For texts with an appropriate connective, there were no differences between the acceptability of the three types of coherence relation ($F_s < 1$). For texts in either the inappropriate or *and* condition, the acceptability depended on the target coherence relation ($F_s > 9.00$, $ps < .001$). For texts containing an inappropriately placed connective, the adversative connectives were more likely to be judged as making sense than the temporal or causal connectives ($ps < .05$), which did not differ. For the items linked by *and*, sense judgments were in the order of: causal $>$ temporal $>$ adversative ($ps < .05$).

The predicted interaction between age and link tended towards significance by subjects ($F_1(2, 178) = 2.52$, $p = .08$) and was significant by-items ($F_2(1, 33) = 3.54$, $p < .05$, $\eta^2_p = .10$). Both age groups were most likely to judge the items linked by an appropriately placed connective as making sense and least likely to judge those linked by an inappropriate connective as making sense: appropriate $>$ and $>$ inappropriate ($ps < .05$). The two age groups did not differ in their acceptance of materials linked either by an appropriate connective or by *and* ($ps > .20$). However, the 10-year-olds were less likely to incorrectly judge items in the inappropriate condition as sensible compared to the 8-year-olds ($p < .01$). None of the other interactions with age group reached conventional levels of significance (all $F_s < 1.88$, $ps > .11$).

TABLE 3 AROUND HERE

Analysis of (ms per character) reading times. As suggested by Trueswell, Tanenhaus and Garnsey (1994), the reading times of the sentences were transformed to millisecond per character reading time to take sentence length differences into account. All datapoints more than 2.5 standard deviations about a participant's mean for that condition were replaced by the appropriate 2.5 SD cutoff score, which

resulted in the replacement of less than 1.5% of datapoints. The distribution of each condition was found to be within acceptable limits. The mean reading times for the critical two clauses in sentence 2 are reported in Table 3.

Two analyses of variance (one with subjects and one with items as the random variable) were conducted with the following factors: age group (10 years, 8 years), coherence relation (temporal, causal, adversative), link (appropriate connective, no connective, inappropriate connective), and part of text (sentence 1, sentence 2, sentence 3). The 10-year-olds read more quickly than the 8-year-olds ($F_1(1,89) = 10.60, p < .005, \eta^2_p = .10$; $F_2(1, 33) = 317.68, p < .001, \eta^2_p = .91$). The reading time for causal connectives ($M=135.9$) was faster than that obtained for temporal ($M = 139.4$) or adversative connectives ($M=137.2$), but this was significant only in the by-subjects analysis ($F_1(2,178) = 6.43, p < .01, \eta^2_p = .07$; $F_2 < 1$). In general, texts in the appropriate condition were read most quickly and those in the inappropriate condition were read most slowly ($F_1(2,178) = 40.88, p < .001, \eta^2_p = .32$; $F_2(2, 66) = 17.46, p < .001, \eta^2_p = .34$). Reading times were longest for the first sentence ($F_1(2,178) = 32.27, p < .001, \eta^2_p = .27$; $F_2(2, 66) = 10.37, p < .001, \eta^2_p = .24$).

FIGURE 2 AROUND HERE

The predicted two-way interaction involving link and part of text was significant in both analyses ($F_1(4,356) = 25.35, p < .001, \eta^2_p = .22, F_2(4,132) = 19.24, p < .001, \eta^2_p = .37$). This is depicted in Figure 2. Sentence 1 reading times were comparable for each type of link ($ps > .20$). The reading times for sentences 2 and 3 were influenced by the type of link. For sentence 2, texts linked by an appropriate connective were read more quickly than those linked by *and* and those linked by an inappropriately placed connective ($ps < .05$). For sentence 3, the reading times in the appropriate and the *and* conditions were significantly faster than in the inappropriate

condition ($ps < .05$). Examining each type of link, there were differences in the reading speed of different sentences. Reading times in the appropriate condition were significantly faster for sentences 2 and 3 relative to sentence 1 ($ps < .001$), but the difference in reading times between sentences 2 and 3 did not reach conventional levels of significance ($p = .06$). In contrast, reading times were longer for sentence 2 than for sentence 3 in both the *and* and the inappropriate conditions ($ps < .05$).

There was an unpredicted significant interaction between coherence relation and sentence in the by-subjects analysis ($F_1(4,356) = 7.97, p < .001, \eta^2_p = .08$), which did not approach significance in the by-items analysis ($F_1 < 1$). The interaction in the by-subjects analysis arose because sentence 2 was read more quickly than sentence 1 in the causal connective condition ($p < .001$), a pattern that was not evident for other types of coherence relations. Because the by-items analysis was not significant, the individual item means were inspected. Of note, reading patterns for adversative connective items differed and they did not all mirror the pattern found in the main analysis. For five of these items, reading times were faster in sentence 2 than in sentence 1. No other interactions reached significance (all $F_s < 2.3, ps > .05$).

Discussion

Both the sense and reading time data demonstrate that young readers' processing and comprehension of text is influenced by the connective used to link two clauses. The sense judgments showed that texts containing inappropriately placed connectives were less acceptable than sentences linked by either *and* or appropriate connectives for each type of coherence relation. Further, for causal and adversative items, the use of *and* did result in significantly lower sense judgments. Similar to Experiment 2, 10-year-olds were more likely to reject texts with inappropriately placed connectives than were 8-year-olds. In Experiment 2, this pattern was found for causal and adversative

coherence relations. In Experiment 3, this pattern was evident for all types of coherence relation.

Reading times for the crucial sentence containing the connective were significantly shorter in the condition with the appropriate connective relative to the other conditions. These data suggest that the presence of an appropriate connective may facilitate processing of text, because the connective signals the relation between two clauses and, therefore, how to integrate their meanings. An alternative explanation is that the presence of either a neutral (*and*) or inappropriately placed connective disrupted processing. For all types of coherence relation, longer reading times were evident in these conditions.

Longer reading times for sentences linked by *and* may be indicative of the time spent computing the appropriate relation between two clauses, which is implied but not stated. Alternatively, the longer reading time may arise if the presence of *and* blocks possible causal interpretations, e.g., “John started to cry because/and George hit him”. An examination of our materials did not identify any positions in the materials when *and* could have blocked the causal reading. Longer reading times for sentences linked by an inappropriately placed connective may have a different source. Readers may try to ‘repair’ their failure to comprehend when the text that comes after the connective cannot be integrated with the situation model that the reader is constructing.

The longer reading times for sentences containing an inappropriately placed connective seen in sentences 2 and 3 support the ‘disruption’ explanation, as do the sense judgments. The mean sense ratings obtained for *and* indicated that these sentences were judged to be coherent by the majority of readers. Further, these ratings were significantly higher than those awarded in the inappropriate condition. Together,

these data suggest that when clauses are connected by *and*, young readers are able to compute their relationship and integrate their meanings, albeit with a processing cost. The longer reading times and lower acceptance for texts in the inappropriate condition, indicate that these texts caused the readers some difficulty and that the integration problem was often not resolved. Although the younger children had longer reading times in general, age group was not involved in any significant interactions in the reading time analysis, indicating that both groups were affected similarly by the different coherence relations. This is in contrast to the findings of the off-line sense measure (and Experiments 1 and 2), where differences between 10- and 8-year-olds were apparent.

The predicted interactions were significant in both analyses. Exploration of the unpredicted interaction between coherence relation and part of text indicated that the reading pattern of some connectives did not mirror that of others of the same type. The means in this interaction were collapsed over type of link. The absence of a significant interaction in the by-items analysis indicates that we need to consider how the benefits of (or disruption caused by) a given connective vary according to the context and the strength of the semantic relation conveyed by the two clauses.

Experiment 4

The sense judgment task and the inclusion of inappropriately placed connectives in the previous experiment may have focused readers' attention on the relation between clauses and resulted in strategic reading. Experiment 4 compared reading times for critical two-clause sentences linked either by an appropriate connective or no connective, followed by questions to tap memory for details of the text to encourage reading for meaning. The aim was to minimize strategic processing and to investigate specifically the benefits of the presence of an appropriate connective. Based on the

findings of Experiment 3, young readers readily benefit from appropriate connectives when reading, which should lead to reduced reading times for the second clause in the presence of the appropriate connective and better comprehension scores in the appropriate condition.

Method

Participants. Two groups participated: 24 10-year-olds (9 boys, 15 girls) and 24 8-year-olds (6 boys, 18 girls).

Materials and design. The texts used in Experiment 3 were modified. There were two versions of each of the 36 texts: one in which the two clauses of sentence 2 were explicitly related by an appropriate connective, and one in which the two clauses were presented as separate sentences without a connective. For ease of exposition, we refer to these segments as clause 1 and 2 for both conditions. The critical two-clause sentence was presented in two frames. The first contained the first clause and the final word was the connective (in the connective condition), the second contained the second clause. Two memory questions (one with a ‘yes’ response, the other with a ‘no’ response) were written for each text. Two lists were created, each containing 18 texts (3 for each connective) with an appropriate connective and 18 texts with no connective. Each participant completed one of these lists.

Procedure. Each child was tested individually in a quiet room. The texts were presented on a computer laptop screen using a procedure similar to Experiment 3. Before the experimental items were administered, participants completed four practice stories. The reading time for each sentence and response times and accuracy to the questions were measured.

Results

Responses to questions. The total number of correct responses to the comprehension questions was high. The 10-year-olds obtained an average score of 5.71 (SD=.27) and the 8-year-olds an average score of 5.47 (SD=.38) (maximum possible score of 6). Because of the ceiling levels of performance these data were not subjected to statistical analysis.

Analysis of (ms per character) reading times. Datapoints were treated using the same procedure described for Experiment 3, which resulted in the replacement of less than 1.5% of datapoints. The distribution of each condition was found to be within acceptable limits. The mean reading times for the critical two clauses in sentence 2 are reported in Table 4. For each age group, reading times were longer when no connective was present for both clauses, with a greater difference between conditions for the second clause.

The reading time data were analyzed in two analyses of variance with the following factors: age (10 years, 8 years), type of coherence relation (temporal, causal, adversative), presence of connective (appropriate connective, no connective), and part of text (sentence 1, sentence 2 clause 1, sentence 2 clause 2, sentence 3). In one analysis, subjects were treated as a random variable and, in the other, items were treated as a random variable. Data for all trials were analyzed because of the high performance on the comprehension questions.

TABLE 4 AROUND HERE

The four main effects were significant. As in Experiment 3, the 10-year-olds read more quickly than the 8-year-olds ($F_1(1,46) = 4.04, p = .05, \eta^2_p = .08$; $F_2(1,33) = 530.23, p < .001, \eta^2_p = .94$) and reading times were quickest for causal connectives in the by-subjects analysis ($F_1(2,92) = 14.74, p < .001, \eta^2_p = .24$; $F_2(2,33) = 1.62, p > .20, \eta^2_p = .09$). Texts were read more quickly when a connective was present ($F_1(1,46)$

= 9.69, $p < .01$, $\eta^2_p = .17$; $F_2(1,46) = 8.33$, $p < .01$, $\eta^2_p = .20$). Finally, participants spent longer reading the first sentence and the second clause of the second sentence than other parts of text ($F_1(3,138) = 109.14$, $p < .001$, $\eta^2_p = .70$; $F_2(3,99) = 32.19$, $p < .001$, $\eta^2_p = .49$).

As predicted, there was a significant two-way interaction between connective presence and part of text ($F_1(3,138) = 7.14$, $p < .001$, $\eta^2_p = .13$, $F_2(3,99) = 9.97$, $p < .001$, $\eta^2_p = .23$), which is depicted in Figure 3. The presence of a connective did not influence reading times for sentences 1 and 3 ($ps > .30$). In contrast, reading times were significantly quicker for clauses 1 and 2 of the second sentence when the connective was present ($ps < .001$). The presence of a connective also influenced reading times for the sentences within each condition. When the connective was present, the first clause of sentence 2 was read more quickly than sentence 1 ($ps < .01$), but this difference was not significant in the no connective condition ($ps > .10$).

FIGURE 3 AROUND HERE

There were two unpredicted interactions, which reached significance in one analysis but not the other. The first involved part of text and year group and was significant in the by-items analysis only ($F_2(3,99) = 4.64$, $p < .01$, $\eta^2_p = .12$). It arose because the 10-year-olds were quicker to read the first sentence and set up their text representation. The second involved coherence relation and part of text ($F_1(6,276) = 9.36$, $p < .001$, $\eta^2_p = .17$) and was not significant in the by-items analysis. In general, the difference in reading times between clauses 1 and 2 was smaller in the causal condition, than in the temporal and adversative conditions, and clause 2 was read more quickly in the causal condition than in the other two conditions. Because the interaction was not significant in the by-items analysis, individual item means were inspected to identify which items did not follow this pattern. For four of the 12 causal

items, reading times were quicker for the second clause. Reasons for this pattern are discussed below. No other interactions reached conventional levels of significance (all $F_s < 2.5$, $p_s > .05$).

Discussion

As predicted, the presence of an appropriate connective facilitated processing of two-clause sentences embedded in short texts. Further, age differences appeared to be largely quantitative rather than qualitative, due to the absence of significant interactions with age (the exception being the time taken to read and represent the information in the first sentence). The faster reading times for the first clause when the connective was present (at the end of the clause) has at least possible two origins. First, when the connective was present, readers may have pressed the button to read on, because a continuation was signaled. Second, when no connective was present (and the clause was a complete sentence), the longer reading time may be indicative of sentence wrap-up effects (Just, Carpenter, & Woolley, 1982). The second clause in each text was identical. Neither sentence wrap up costs nor the presence of a connective can explain the shorter reading times for this clause when it followed a connective. Therefore, the most plausible conclusion is that appropriate connectives facilitated text processing.

The unpredicted interaction between coherence relation and part of sentence warrants consideration. The means were collapsed over the presence of a connective. Thus, the general pattern suggests that the causal items were easier to process, regardless of connective presence. Another possibility is that absence of a causal connective did not result in the same processing cost as the absence of a temporal or adversative connective. The latter explanation is supported by a wealth of research that demonstrates that young readers strive for causal coherence when processing

narratives from an early age (van den Broek, 1997). Thus, one possibility is that readers expect to find causality in narratives and readily infer such relations. Because the interaction was not significant by items, we need to be cautious in our interpretation, because the sentence context in which the connective is present (or absent) may have influenced processing as well.

General Discussion

The interpretation and use of connectives when reading is crucial to the construction of a coherent situation model of a text, the hallmark of successful comprehension. These experiments found a mixed picture of competence in young readers' processing and comprehension of connectives that signal different coherence relations. The off-line measures indicate that young readers' explicit knowledge of connectives has not reached adult levels. Experiments 1 and 2 showed that 10-year-olds often reach adult levels of performance, whereas 8-year-olds differ from 10-year-olds in their ability to select appropriate connectives to join two clauses and to discriminate appropriate and inappropriate uses. Thus, although we have clear evidence that young readers have reasonable knowledge about connectives that signal a range of coherence relations and are sensitive to whether a connective is used appropriately to link two events, their competence is still developing. The on-line measures suggest that readers as young as 8 years can use the information provided by connectives as they read. They process two-clause sentences more quickly when they contain an appropriate connective and take longer to process a sentence when the connective is either neutral (e.g., *and*) or when there is no connective, and also when the connective is inappropriately placed, i.e., it does not match the meaning conveyed by the two clauses. Thus, although young readers' knowledge about connectives is

still developing, they behave similarly to adult readers and appear to use connectives as processing signals as they read (e.g., Mouchon et al., 1995).

This work adds to the growing body of research on cohesion and coherence in text comprehension, and the important role for connectives in the construction of an integrated and accurate meaning-based representation of a text (Gernsbacher, 1997; Graesser et al., 2007; Sanders & Noordman, 2000; Segal, Duchan, & Scott, 1991). Our findings demonstrate that young readers do not automatically process sensible relations between clauses when a connective is not present, because we found specific benefits for the presence of appropriate connectives. Further, we have shown that text integration does not benefit from the presence of a connective per se: the use of *and* led to longer reading times relative to the presence of an appropriate connective for all types of connectives, and also lower acceptability, as measured by sense judgments. The presence of *and* might indicate that there is some general link between two clauses, but the specific connective resulted in quicker reading times in our experiments. In addition, the presence of an appropriate connective resulted in faster processing relative to when no connective was present.

These findings highlight the importance of strategically placed connectives in texts for young readers. They suggest that, in contrast to the conclusions of text readability formulae, a longer sentence in which the link between two clauses is explicitly signaled may be easier to understand than two short separate sentences, if the individual has reached a certain level of knowledge of the specific connective. Thus, appropriate and informative connectives appear to help, not hinder, young readers to process and understand written text. Connectives, as well as other markers of text cohesion, should inform calculations of text complexity to identify suitable texts for different levels of reader.

Developmental differences in connective knowledge were apparent in this research and previous studies that have used off-line measures (e.g., (Cain et al., 2005; McClure & Geva, 1983). These findings suggest that the potential benefits from connectives in text are not the same for all readers and are dependent on knowledge. Our first two experiments allowed time for participants to reflect on each sentence and enabled a considered selection of the appropriate connective or rating of sense. Experiment 3 involved a sense judgment when the text was no longer available for scrutiny, which did not require a speeded response. The metalinguistic skills involved in these tasks are still developing in young readers (Gombert, 1992). This might underlie the poorer performance by 8-year-olds, although it is important to note that their level of performance indicated a reasonable degree of knowledge of all the connectives used. Cloze measures are frequently used in the classroom to assess competence. Educators should be mindful that use of such tasks might underestimate a child's ability to process the relation signaled by a connective.

More pronounced developmental differences might be apparent with different texts and tasks. All of our sentences and texts had a narrative theme. Previous work has highlighted the specific role of connectives and other cohesive devices in comprehension for learning. Sanders and colleagues have shown that, for adult readers, connectives influence both processing and comprehension of expository text, indicating that these markers may be important for acquiring new information from text (Degand & Sanders, 2002; Kamalski, Sanders, & Lentz, 2008; Sanders & Noordman, 2000). Readers with less prior knowledge benefit more from the presence of connectives and other devices that signal relations between information (Kamalski et al., 2008; McNamara & Kintsch, 1996). When reading to learn from information sources such as textbooks and newspapers, age differences may be greater if older

readers are better able to use connectives to fully understand the relation between different facts and events in a text. In relation to further exploration of the development of connective comprehension, clearly reading time paradigms are not suitable for pre-readers or beginner readers. Other methods such as timed sense judgments using aurally presented text could offer an insight into how early in development children use connectives automatically when processing and comprehending spoken language.

Further, differences between age groups and different types of coherence relation may be stronger in other classroom tasks, in which children have to make metacognitive judgments about which connective to use, such as written language production. For that reason, we would anticipate greater age effects in writing tasks, where the (child) author has to select the appropriate connective to establish coherence. Such issues should be addressed in future research with young readers.

Some limitations should be noted. Clearly our experimenter-generated sentences, sentence-pairs and short texts differ from the naturalistic, longer, texts that children encounter in everyday reading situations. For that reason, we run the risk of describing the impact of connectives on less cognitively demanding reading than that required for understanding the books that children engage with in school or in their leisure time. However, our carefully constructed and controlled texts have enabled us to demonstrate how even young readers can benefit from connectives when reading for meaning. This general finding suggests that connectives should inform assessments of text complexity.

Although we included two connectives for each type of coherence relation, we did not examine these separately. It may be important to do this in future research for two reasons. First, the familiarity of a particular connective may influence

performance, in addition to the type of coherence relation it signals (Crosson et al., 2009). Although the six connectives used in this study differed in word frequency, examination of performance for each connective indicated that performance differences were not always in line with frequency differences. Second, within the group of connectives that express a particular type of coherence relation, different connectives signal different orders of temporality, causality, or contrast, as outlined in the introduction. It may be more important to consider comprehension of specific connectives rather than types of coherence relation, because the connectives within a particular classification signal different relations between events (Murray, 1997), differ in frequency, and also cognitive complexity (Evers-Vermeul & Sanders, 2009; Spooren & Sanders, 2008). For example, production studies indicate that acquisition is influenced by the cognitive complexity of the specific coherence relation. Future work should explore how these factors influence young readers' comprehension.

In sum, this is the only systematic investigation to date of young readers' processing and comprehension of a range of connectives. These findings have important implications for our understanding of the development of reading comprehension in general and for the design of curricula and educational texts. We have demonstrated that young readers possess an adequate understanding of a range of connectives and are able to take advantage of information provided by connectives as they read. However, their explicit understanding appears to lag their ability to benefit from these signals whilst reading, which may influence other tasks such as written text production. These findings point to an important role for connectives in the construction of coherent situation models of text from an early age and demonstrate that connectives help (not hinder) young children to process and establish coherence in text. We conclude that connectives could play a useful role in

educational texts, and should be taken into account when evaluating the complexity of a text and its suitability for different readers.

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Table 1

Experiment 1. Mean Proportion Correct (and Standard Deviations) by Age and Type of Coherence Relation

	temporal	causal	adversative
Adults	.98 (.04)	.92 (.06)	.97 (.04)
10-year-olds	.86 (.13)	.80 (.15)	.88 (.14)
8-year-olds	.77 (.17)	.78 (.14)	.78 (.21)

Table 2

Experiment 2. Mean Sense Ratings (and Standard Deviations) by Age, Type of Coherence Relation, and Link

	temporal		causal		adversative	
	approp.	inapp.	approp.	inapp.	approp.	inapp.
Adults	3.82 (.23)	2.05 (.49)	3.86 (.30)	2.03 (.57)	3.81 (.16)	1.96 (.47)
10-year-olds	3.55 (.31)	1.85 (.44)	3.79 (.25)	1.94 (.51)	3.37 (.38)	1.95 (.39)
8-year-olds	3.35 (.34)	1.98 (.47)	3.60 (.29)	2.18 (.52)	3.03 (.44)	2.03 (.42)

Note. approp. = appropriate; inapp. = inappropriate. Maximum possible score for each cell is 5.

Table 3.

Experiment 3. Proportion 'Makes Sense' Judgments, Mean Reading Times in ms per Character for Sentence Two (and Standard Deviations) by Age, Type of Coherence Relation, and Link

		temporal			causal			adversative		
		approp	and	inapprop	approp	and	inapprop	approp	and	inapprop
10-	Sense	.96	.64	.31	.90	.76	.50	.91	.80	.44
		(.11)	(.20)	(.29)	(.17)	(.23)	(.34)	(.16)	(.25)	(.27)
	RT	113.84	144.07	145.53	107.02	126.37	132.64	110.45	130.37	146.51
		(29.86)	(37.26)	(31.34)	(31.76)	(31.14)	(30.76)	(30.05)	(34.34)	(39.21)
8-	Sense	.89	.66	.46	.93	.80	.57	.89	.84	.47
		(.16)	(.22)	(.27)	(.15)	(.20)	(.29)	(.18)	(.19)	(.31)
	RT	135.32	158.31	158.26	123.67	144.83	157.07	135.95	146.95	165.48
		(37.12)	(42.76)	(38.33)	(36.87)	(49.29)	(46.00)	(35.45)	(38.80)	(43.69)

Note. approp = appropriate; inapprop = inappropriate

Table 4

Experiment 4. Mean Reading Times in ms per Character for Sentence Two (and Standard Deviations) by Age, Type of Coherence Relation, and Link

temporal connectives					
		connective present		no connective	
		clause 1	clause 2	clause 1	clause 2
10-year-olds		97.06	128.38	108.22	141.01
		(33.54)	(35.81)	(47.22)	(44.58)
8-year-olds		123.85	155.07	134.42	169.08
		(54.84)	(59.29)	(63.77)	(65.07)
causal connectives					
		connective present		no connective	
		clause 1	clause 2	clause 1	clause 2
10-year-olds		97.10	117.37	111.77	121.90
		(37.57)	(32.24)	(49.93)	(37.63)
8-year-olds		122.51	138.33	134.77	151.36
		(52.80)	(47.20)	(62.19)	(61.05)
adversative connectives					
		connective present		no connective	
		clause 1	clause 2	clause 1	clause 2
10-year-olds		101.23	131.04	109.62	142.30
		(40.27)	(35.09)	(40.39)	(42.87)
8-year-olds		130.41	164.88	127.82	176.60
		(60.72)	(57.64)	(51.33)	(70.44)

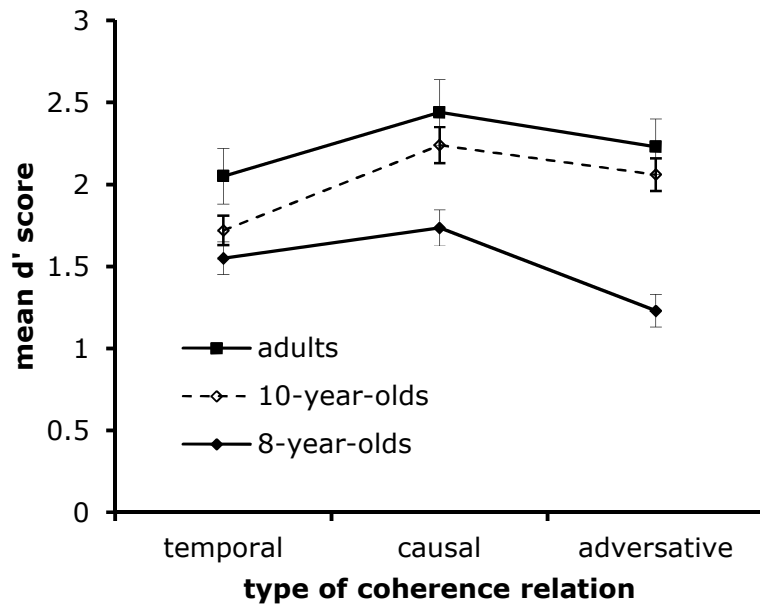


Figure 1. Experiment 2. Mean d' scores by age group and type of coherence relation (with standard error bars).

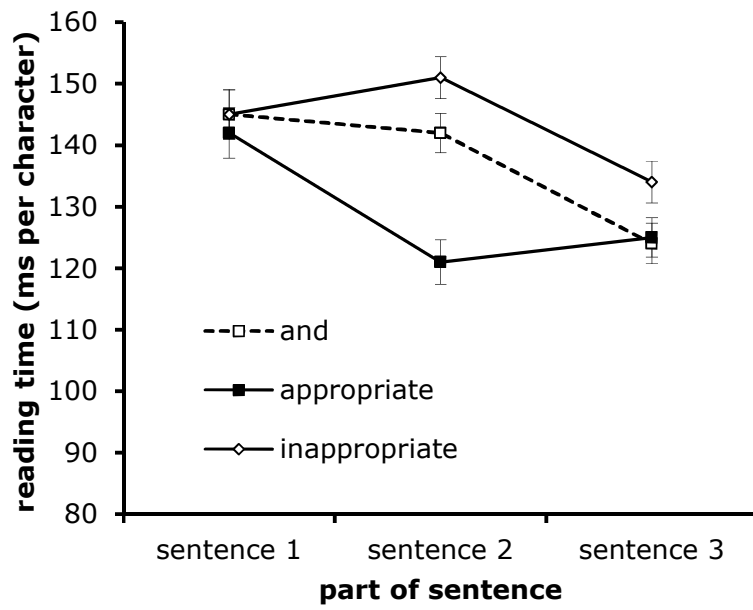


Figure 2. Experiment 3. Interaction between link and sentence (with standard error bars).

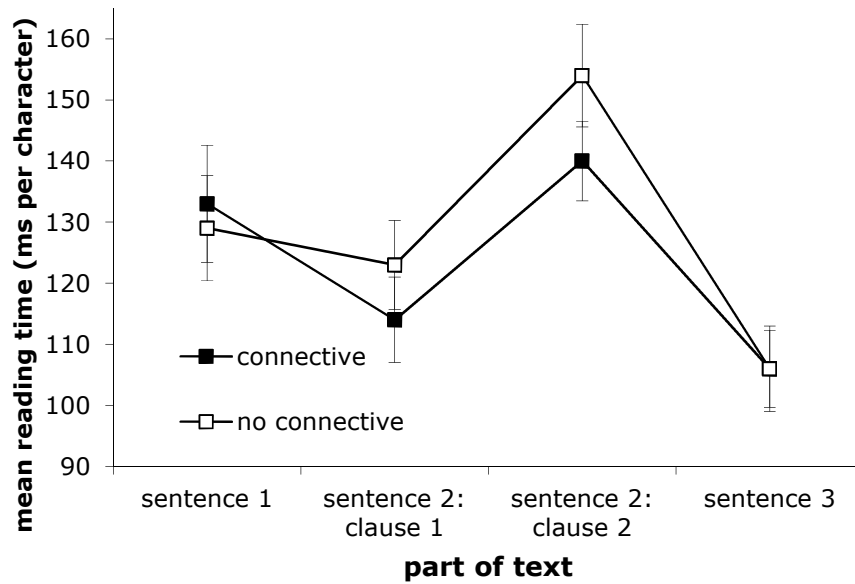


Figure 3. Experiment 4. Interaction between presence of connective and part of sentence (with standard error bars).

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Appendix

Examples of materials used in Experiments 1-3

Experiment	Task	Example of material	
Experiment 1	Cloze task	Sam walked into the lesson after/because/and* it had started. *appropriate/inappropriate/and	
Experiment 2	Sense rating	Molly pressed the doorbell so/because* it rang. *appropriate/inappropriate	
Experiment 3	On-line sense judgment	Experimental text	Amy had always loved dogs. Amy wanted a dog but/after/and* she was not allowed one. Amy's house was too small for a dog. *appropriate/inappropriate/and
		Filler text	Chris knocked the glass off the table. Chris caught the glass and it smashed on the floor. Chris was very lucky.