

CAUSAL LINKING DURING TEXT COMPREHENSION¹

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Summary.—To study the linking of causally related events during reading, sets of 10 to 12 sentences were prepared so each subject was presented 40 texts, 10 within each of four conditions, 2 causal and 2 noncausal, presented on a Macintosh Plus microcomputer. Each text contained a test sentence, for which reading time was registered. Mean reading time was shorter for the two causal conditions than for the two noncausal conditions. It was concluded that during comprehension of text readers engage in causal linking.

To understand text a reader has to relate the meaning of the sentence that he currently processes to that of the preceding context. One characteristic of the resulting text representation is that it reflects the causal relation between the (most important) narrated events, often referred to as the 'causal chain' of the text. Research into causal chaining in text comprehension has both looked at the 'end-products' (Mitchell, 1982) of the comprehension process, that is, the eventual text representation, and at the ongoing comprehension processes. Variables reflecting the end products of comprehension are, for instance, immediate and delayed recall (e.g., Trabasso & Van den Broek, 1985). A variable reflecting on-line comprehension is sentence reading time (e.g., Myers, Shinjo, & Duffy, 1987).

Myers, *et al.* (1987) presented their subjects stimuli consisting of two sentences each. Reading time of the second sentence served as one of the dependent variables. The first sentence within a stimulus described an event that, to a greater or lesser extent, caused the event narrated in the second sentence. It turned out that reading time of the second sentence increased with decreasing causal strength between the sentences within a stimulus.

The study by Myers, *et al.* (1987) may overestimate the extent to which readers normally relate sentences causally: the fact that the stimuli consisted of two sentences only, may have emphasized the causal relation between them, and this may have introduced an unnatural processing strategy. More than with more common text subjects may have looked for causal connections between the sentences.

Following Myers, *et al.* (1987), in the present study we investigated the linking of causally related events *during* reading. However, in contrast to this earlier study, we presented text fragments with more than one sentence as prior text. The prior text always consisted of four or five sentences

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describing an event or situation in which two main characters figured. The test sentence, for which reading times were measured, described the reaction of one of these main characters to this event. In two experimental conditions, the 'causal' conditions, this reaction was a natural consequence of the event described in the prior text. In two further conditions, the 'noncausal' conditions, the reaction did not fit in easily with the event described before. The word 'because' never occurred in the texts, so causality was never signalled explicitly. More detailed information about the stimulus materials is provided below. The main question posed here is whether with this type of materials causal linking during text comprehension occurs. If such is indeed the case, reading time for the test sentences should be shorter in the causal conditions than in the noncausal conditions.

METHOD

Materials and Design

The test materials consisted of 20 texts comprised of 10 to 12 sentences each. Sentences 1 through 4 within each text described an event in which two main characters figured. Sentence 6 was the test sentence for which reading times were to be registered. This sentence narrated the reaction of one of the main characters introduced in Sentences 1 through 4 to the event described therein. For each set of Sentences 1 through 4, two versions of the test sentence were created. In one version (6a) the reaction of the character was a natural consequence of the event described in Sentences 1 through 4. In the second version (6b) the reaction of the main character was unexpected given the event depicted in Sentences 1 through 4. Generally, Sentence 6b was created out of 6a by replacing a number of words from the latter by new ones. The resulting Sentence 6b had the same grammatical structure and was of approximately the same length as the 'base' Sentence (6a). Mean length of the 6a- and 6b-sentences was 12.7 and 13.2 syllables, respectively. Sentence 5 within each of the 20 texts (the 'reversal' sentence) described an experience of one of the main characters introduced in Sentences 1 through 4, or provided additional information on that character, that reversed the relation between Sentences 1 through 4 on the one hand and the 6a- and 6b-sentences on the other: with the inclusion of Sentence 5 in the prior text, 6b became the natural and 6a the unexpected consequence of the events described in the prior text. In short, Sentences 1 through 4 immediately followed by Sentence 6a, or followed first by Sentence 5 and then by Sentence 6b, constituted two conditions narrating a natural sequence of events. These two conditions will be referred to as causal. In contrast, Sentences 1 through 4 immediately followed by Sentence 6b, or followed first by Sentence 5 and then by Sentence 6a, narrated a sequence of events among which the last was unexpected. These

conditions will be referred to as noncausal. Three example sets of Sentences 1 through 6 are presented in Table 1. The test sentence (6a or 6b) in each of the 20 texts was followed by a concluding text fragment consisting of 4 to 7 sentences. The length of this fragment was varied to prevent the subjects from selectively attending to particular parts of the texts.

TABLE 1
EXAMPLES OF THE CRITICAL PARTS OF EXPERIMENTAL TEXTS

Example 1	
1	The shop owner stood near the pay-cash-desk when Patricia walked in.
2	Last week he had thrown her out.
3	He had caught her stealing.
4	Now he hurried towards her.
5	(He felt sorry for having treated her that way.)
6a	He started to talk to her in a stern voice.
6b	He started to talk to her in a gentle voice.
Example 2	
1	Stephan came across something odd in the latest issue of the journal.
2	It was an article by Paula communicating his idea.
3	During their last meeting he had told her about it.
4	He walked up to her room right away.
5	(He thought she'd improved it considerably.)
6a	Furiously he sat down on the chair that she offered him.
6b	Good-humoured he sat down on the chair that she offered him.
Example 3	
1	Andrew hoed away the last weeds when aunty arrived.
2	Every month he took care of her garden.
3	That way he eked out his pocket-money.
4	Together they walked into the kitchen.
5	(To her dismay she saw that everything was covered with mud.)
6a	She complimented him while he cleaned his hands.
6b	She rebuked him while he cleaned his hands.

Each single subject was presented 40 texts, 10 within each of the four experimental conditions, 2 causal and 2 noncausal, formed by the combined manipulations on the test sentence (6a vs 6b) and on Sentence 5 (present vs absent). Since there were only 20 different texts (see above), the same text was presented to every single subject in two different versions, with each of the two versions corresponding to a different condition. Prior to the actual experiment, four texts, all different from any of the experimental texts, were presented for practice.

The appropriateness of the selected materials was assessed by presenting each of 32 subjects, none of whom participated in the main experiment, but drawn from the same population, 20 text fragments. They were asked to indicate on a 7-point scale how good a continuation of the earlier sentences the last sentence of each fragment was (1: very bad; 7: very good). The pre-

sented text fragments were the *critical* parts of the experimental materials of the main experiment, concluding with the test sentences of that experiment. Every single subject received five text fragments belonging to each of the four experimental conditions, with the constraint that each one saw only a single version of each text (with or without the reversal Sentence 5, and with either 6a or 6b as test sentence). Every subject was tested with a unique assignment of texts to conditions. Across subjects eight ratings per version/per text were obtained.

For each subject a mean rating was calculated for each of the four conditions formed by the two levels of the variables 'reversal sentence' (Sentence 5 present vs absent) and 'test sentence' (6a vs 6b). A 2 (reversal sentence) by 2 (test sentence) by 32 (subjects) analysis of variance was performed on these means, treating both variables as within-subjects variables. The main effects of reversal sentence and test sentence were both significant ($F_{1,31} = 4.19$, $p < .05$, and $F_{1,31} = 7.09$, $p < .05$, respectively): the mean good-continuation rating for the text fragments including the reversal sentence, collapsed across the levels of the test-sentence variable, was slightly smaller than that for the text fragments not including the reversal sentence (4.17 vs 4.47). The mean good-continuation rating for the text fragments with 6a as test sentence, collapsed across the levels of the reversal-sentence variable, was slightly larger than that for the text fragments with 6b as test sentence (4.52 vs 4.11). These main effects, both of them collapsing the data of one causal and one noncausal condition, are less interesting than the interaction between the two variables, which was significant ($F_{1,31} = 213.11$, $p < .0001$). The mean ratings for the two causal conditions were both considerably higher than those for the two noncausal conditions (Sentence 5 absent/6a: 5.79; Sentence 5 present/6b: 5.09; Sentence 5 absent/6b: 3.14; Sentence 5 present/6a: 3.25). The constructed materials thus seemed fit for the present purposes.

Subjects

Thirty students of the University of Amsterdam participated as subjects. Of them, 24 participated in partial fulfillment of a course requirement and 6 participated voluntarily.

Apparatus and Procedure

The experiment was run on a Macintosh Plus microcomputer. The subjects were tested individually. The 4 practice and 40 experimental texts were presented sentence by sentence. The subject was asked to read each sentence silently and to press the space bar on the computer keyboard as soon as he had finished reading it. The sentence immediately disappeared and a new one appeared. The time between the subject pressing the space bar as a result of which a test sentence first appeared and his subsequent

pressing as a result of which it disappeared again, was registered as its reading time. After the completion of a text, a yes/no question concerning that text was presented on the screen. Across texts, each part of the text (beginning, middle, and end) about equally often contained the information relevant to answer the question. The subjects answered the question by 'clicking' on a 'yes' or a 'no' window on the screen. Immediately afterwards a message appeared indicating the appropriateness of the subject's answer. Approximately three seconds later the first sentence of the next text appeared. The 40 texts were presented in a random order, a new order for every following subject, but with the constraint that at least 10 different texts were presented in between the presentation of the two versions of the same text (see section on materials). There was a 2-min. break halfway through the experiment, which was filled with counting backward by threes, e.g., 1500, 1497, 1494, and so on.

RESULTS

For each subject a mean RT was calculated for each of the four conditions formed by the two levels of both of the variables reversal sentence and test sentence. RTs shorter than 400 msec. (12 in all) and longer than 5500 msec. (13 in all) were replaced by these boundary values. Together they constituted 2.1% of the data. A 2 (reversal sentence) by 2 (test sentence) by 30 (subjects) analysis of variance was performed on these means, treating both

TABLE 2
MEAN READING TIMES FOR TEST SENTENCES (IN MSEC.) AND STANDARD DEVIATIONS
FOR FOUR REVERSAL SENTENCE BY TEST SENTENCE CONDITIONS

Test Sentence	Reversal Sentence			
	Absent		Present	
	M_{RT}	SD	M_{RT}	SD
6a	1663	562	1889	613
6b	1861	713	1666	616

variables as within-subjects variables. Furthermore, the corresponding 2 by 2 by 20 (texts) was performed on the item means, collapsed across subjects. In this analysis the variable reversal sentence was treated as a within-items variable, since across the levels of this variable the same *test* sentences were presented. The variable test sentence was treated as a between-items variable. In neither of the two analyses the main effects of reversal sentence and test sentence were significant ($F < 1.00$ in all cases). Indeed, no significant main effects were expected, because on both levels of both variables the data of one causal and one noncausal condition were collapsed. However, the relevant effect, the interaction between the two variables, was statistically reliable on both the subject and the item analysis ($F_{1,29} = 28.90$,

$p < .001$; $F_{2,38} = 11.10$, $p < .01$). Table 2 presents the over-all mean reading times for the test sentences and the corresponding standard deviations for each of the four reversal sentence by test sentence conditions. The input for the measures of standard deviation in this table were the mean reading times of all individual subjects for each of the four different conditions, collapsed across the 10 texts within each of these conditions.

As can be seen in Table 2, the test sentences in the two causal conditions (5 absent/6a and 5 present/6b) were read faster than the test sentences in the two noncausal conditions (5 present/6a and 5 absent/6b). Furthermore, even though causal relatedness was effected in two different ways, with different test sentences across the two causal conditions, these two conditions showed about equally long reading times for the test sentences. This is also the case with the two noncausal conditions. The differences in RT between the two causal conditions and that between the two noncausal conditions were nonsignificant ($p > .10$). All four differences between one causal and one noncausal condition were statistically reliable ($p < .01$ in all cases). When collapsing the data of the two causal conditions and those of the two noncausal conditions, 25 out of the 30 subjects and 16 out of the 20 texts showed shorter reading times in the causal condition than in the noncausal condition.

These results point out that during comprehension of text readers engage in the type of causal linking investigated in this study.

REFERENCES

- MITCHELL, D. C. (1982) *The process of reading: a cognitive analysis of fluent reading and learning to read*. Chichester, Eng.: Wiley.
- MYERS, J. L., SHINJO, M., & DUFFY, S. A. (1987) Degree of causal relatedness and memory. *Journal of Memory and Language*, 26, 453-465.
- TRABASSO, T., & VAN DEN BROEK, P. (1985) Causal thinking and the representation of narrative events. *Journal of Memory and Language*, 24, 612-630.

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