JOURNAL OF VERBAL LEARNING AND VERBAL BEHAVIOR 17, 509–521 (1978)

Interclause Relations and Clausal Processing

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In two experiments subjects were interrupted while listening to a two-clause sentence just before the last word of either the initial clause or the final clause. In Experiment I subjects were timed on their decision about whether a verb–object phrase was consistent in meaning with the sentence fragment they had just heard. Overall these decisions were made more quickly when a main clause was interrupted than when a subordinate clause was interrupted, but the size and direction of main–subordinate differences varied with the causal–temporal properties of subordinate clauses. In Experiment II subjects were timed on their decisions about whether a particular probe word had occurred in the sentence fragment. Target position effects differed for main and subordinate clauses, but again, these effects were related to causal–temporal relations between clauses. The two experiments together suggest that interclause semantic relations affect the immediate processing of clauses.

To what extent do the semantic and syntactic relations between the clauses of a sentence affect the on-line processing of the individual clauses? While several studies have examined the role of temporal relations (Clark & Clark, 1968; Smith & McMahon, 1970; Fillenbaum, 1971), the assertion–presupposition distinction (Harris, 1974; Offir, 1973; Hornby, 1974), and the main–subordinate distinction (e.g., Foss & Lynch, 1969; Jarvella & Herman, 1972) on performance, the subject's task in these studies has usually occurred after he has heard or read the complete sentence. As a result, these studies do not necessarily demonstrate differences in on-line processing of different types of clauses. More recently, however, studies have shown that surface structure properties within clauses—for example, the explicitness with which the logical roles are expressed (Tanenhaus & Carroll, 1975; Marslen Wilson, Tyler, & Seidenberg, 1978)—affect perceptual segmentation and closure. All of these studies lead us to consider whether the semantic and syntactic role of a clause affects the immediate processing of the clause. More specifically, we consider whether the listener's accessibility to the semantic and literal form of a clause while he hears it differs for main and subordinate clauses, for clauses conveying assertions vs. presuppositions, and for clauses with different causal and temporal roles in the sentence.

In our tasks, the subject hears only a fragment of a sentence, ending before either the last word of the initial clause or the last word of the final clause. The interrupted clause

This research was supported by grants from the National Institute of Mental Health (57352-01) and Montclair State College to the first author. Portions of this research were discussed in papers presented at the NATO Conference on the Psychology of Language, 1976, and the Psychonomic Society meetings, 1977. The authors are grateful to Neal Flieschman and Jean Rouzic for assistance in conducting the experiments, to Aida Capifali, Elba Barnes, and Mollie Morehead for typing the manuscript, and to two anonymous reviewers for comments on an earlier report of this research.

0022–5371/78/0175–0509$02.00/0

in either position is either main or subordinate (introduced by *if*, *since*, *when*, *while*, or *though*). After hearing the fragment, the subject determines whether a visually presented verb–object phrase is similar in meaning to what he heard (Experiment I) or he determines whether a probe word had occurred in the fragment (Experiment II). Reaction times in the former task provide an index of the listener's on-line accessibility to the meaning of the clause he had been hearing. In the latter task, we assume that the subject has maintained the interrupted clause in more superficial form to the extent that his reaction times are longer for target words that had occurred later in the clause. This assumption is based on the view that a superficial representation is searched word by word from "left to right," but that such a search process is impossible in an abstract representation, which, in the extreme case, does not contain information about word order, or even specific words. These tasks differ from those of many previous studies primarily in that they involve a test before the complete clause has been heard. Thus, any differences we find can be attributed to processing that occurs while the clause is being heard. The tasks provide a means of determining whether listeners process clauses with different properties in different ways. The properties under consideration here are the structural, presuppositional, and semantic roles of various clauses.

The conjuctions in this study display a variety of meanings on a causal–temporal dimension. The possible meanings of several conjunctions with respect to the causal–temporal dimension are summarized in Table 1. Occupying one end of this dimension is the *if* clause, which often states a cause for the event in the main clause, as shown in "If Harry takes the arsenic, he'll die." At the other end of the causal–temporal dimension is a *though* clause, which expresses an adversative relation, that is, a denial of an expected cause–effect relation. A *though* clause states an event that ordinarily would lead one to expect a certain effect, but it indicates that the expected effect did not occur (Dakin, 1970). For example, in "Though Harry took the arsenic, he didn't die," the speaker believes that taking arsenic ordinarily causes death.

Many conjunctions have meanings which fall between the causal and adversative extremes, and some conjunctions have multiple meanings. For example, in "Since Harry wrecked his car, he's been taking the bus," the *since* clause may indicate an event that causes the main clause event, or it may simply indicate an event that occurs prior in time to the main clause event. *When* clauses may have three meanings. A *when* clause may indicate, by inference, a cause, as in "When Harry heated the glass, it melted," an event prior in time, as in "When Harry wrecked the car, Bill fixed it," or an event occurring simultaneously with the main clause event, as in "When Harry was raking the leaves, Bill was fixing the car." A *while* clause also expresses several meanings; among these are a simultaneous event, as in "While Harry was raking the leaves, Bill was fixing the car," an event occurring later in time than the main clause event, as in "Harry threw the stick, while the dog retrieved it," or it

TABLE 1

SEMANTIC RELATIONS BETWEEN SUBORDINATE AND MAIN CLAUSES

	Cause	+Prior	Simultaneous	−Prior	Adversative
If	X				
Since	X	X			
When	X	X	X		
While			X	X	X
Though					X

may express an adversative relation, as in "While Harry did take the arsenic, he didn't die".

The particular meaning which is dominant depends on several factors, such as the meanings of the individual clauses, stress, and the order of the clauses. The meanings of the conjunctions, however, are orderly in that there are no discontinuities on the causal–temporal dimension, as shown in Table 1. Furthermore, causal and temporal meanings are associated: Those conjunctions that indicate prior events may, by inference, indicate causal events.

The question we address in this research is whether listeners are sensitive to these differences in causal–temporal meanings during immediate processing. It is well known that postsentence performance is superior for temporal sentences that present the events in their actual order of occurrence and that questions about first events are answered more quickly than questions about second events (Clark & Clark, 1968; Smith & McMahon, 1970; Fillenbaum, 1971; see also Katz & Brent, 1968). These results suggest that temporal sentences are organized in memory in terms of the temporal order of events. In this study, we determine whether the listener conducts this type of organization as he hears the sentence and whether the organization of temporally related events is part of a more general strategy of organizing causally related events. We refer to the prediction that causes and first events are more directly interpreted as the *causal–temporal hypothesis.*

Other types of relations between clauses may be the basis for modifying on-line processing. Structurally, main clauses dominate subordinate clauses in the surface structure tree, and main clauses are more "complete" in that they can stand alone as a sentence. To the extent that the listener reconstructs the surface tree from the top down (Kimball, 1973), or to the extent that more complete clauses serve as better processing units (Tanenhaus & Carroll, 1975), main clauses should be interpreted more directly than subordinate clauses. We refer to this prediction as the *structural hypothesis.*

Main and subordinate clauses also differ in the types of information they convey. Main clauses often express an assertion, but subordinate caluses often express a presupposition (Keenan, 1971; but see also Boer & Lycan, 1976). For example, denying a sentence with a *though, while, when,* or *since* clause appears to deny only the main clause and not the subordinate; hence, these subordinate clauses are said to convey a presupposition. The presuppositions of *if* sentences, however, are more complex, and it is difficult to associate any simple presupposition with the *if* clause (cf., Morgan, 1969). The presupposition–assertion distinction, at least for the clear cases, may serve as the listener's basis for the organization of the two clauses of a sentence. That is, the assertion may be interpreted more directly, since it contains the "new" information, while the presupposition may simply be used to indicate where the new information is to be integrated into memory once it has been understood (cf. Haviland & Clark, 1974; Hornby, 1974). We refer to the prediction that presuppositions are less directly interpreted as they are being heard as the *presuppositional hypothesis.*

In Experiment I we examined the listener's on-line accessibility to the semantic form of a clause. Subjects listened to two-clause sentences, but were interrupted before either the last word of the first clause or the last word of the second clause. At the interruption point, they read and classified a verb–object phrase as being consistent or inconsistent with the meaning of what they had just heard. The interrupted clause varied in its causal–temporal, structural, and presuppositional role in the sentence. The causal–temporal hypothesis predicts that classification time is relatively faster for subordinate clauses that are more explicitly causal. The structural hypothesis predicts that classification time is faster

for main clauses than for subordinate clauses. The presuppositional hypothesis predicts that classification time is faster for assertions than for presuppositions, more specifically, that times are faster for main clauses in *though*, *while*, *when*, and *since* sentences.

EXPERIMENT I

Method

Procedure. The subjects were tested individually, one subject for each of 16 lists. Subjects were instructed to listen to a sentence fragment. Upon hearing a tone, a verb–object phrase in lower case elite letters was projected onto a ground glass screen. The subjects were instructed to read the phrase and decide whether it was similar in meaning to any part of the fragment. They were instructed to say as quickly as possible "yes" if they felt the phrase was consistent in meaning with the fragment, or "no" if they felt it was not consistent in meaning. The sentence fragments were presented with a Sony TC280 tape deck through headphones into the subject's right ear. The tone started a Hunter millisecond timer and simultaneously activated a shutter which allowed the phrase to be projected onto a screen. The subject's vocal response stopped the timer.

Sentence fragments. Sentences for positive and negative trials were constructed with similar constraints. The actual form of each positive sentence varied across lists, but the form of negative sentences was constant across lists. There were 16 positive sentences (four with *while*, and three each with *if*, *since*, *when*, and *though*) and 12 negative sentences (three with *when*, and two each with *if*, *since*, *while*, and *though*). Excluding the conjunction, one clause (the "probed clause") contained 10 or 11 monosyllabic words, and the other contained 12 or 13 syllables. The probed clause contained a word that appeared in one of two positions without changing meaning (see Experiment II). Across lists, each positive sentence appeared in eight forms, depending on the position of the moveable word, the position of the probed clause, and the structural role of the probed clause. A complete set of eight versions of one sentence fragment is shown in (1)–(4):

(1) Initial main: Good jobs are (now) quite scarce (now) in most large . . .

(2) Initial subordinate: Though good jobs are (now) quite scarce(now) in most large . . .

(3) Final main: Though there is little danger of a major depression, good jobs are (now) quite scarce (now) in most large . . .

(4) Final subordinate: There is little danger of a major depression though good jobs are (now) quite scarce (now) in most large . . .

The positive sentences were arranged into a single random order, as were the combinations of the independent variables (position of moveable word, clause structure, clause position) within each block of eight sentences. Eight lists were generated by partially counterbalancing within blocks the combinations of variables across the single random order of positive sentences. Eight additional lists were generated by using the complement of clause position and clause structure for each positive sentence in the first list and again partially counterbalancing.

The 12 negative sentences were randomly placed among the 16 positive sentences and occupied the same relative position in each list. Half of the negative sentences had an initial main clause. Six practice sentences (three with an initial main clause) were placed at the beginning of each list; half of these constituted positive trials.

A male speaker recorded the intact sentences with normal intonation. Fragments were produced by cutting out the last word of the initial clause and the remainder of the sentence for trials in which the initial clause was interrupted, and by cutting out the last word of the final clause for trials in which the final clause was interrupted. A 50-millisecond,

TABLE 2

RESPONSE TIMES FOR JUDGMENTS OF CONSISTENCY OF MEANING[a]

	Initial clause		Final clause	
	Main	Subordinate	Main	Subordinate
Positive trials[b]	1224 (1.6)	1282 (4.7)	1214 (3.1)	1359 (7.8)
Negative trials[c]	1224 (8.3)	1306 (12.5)	1302 (6.3)	1295 (4.2)
Overall	1224	1292	1252	1332

[a] Response times are expressed in milliseconds. The percentage of errors is indicated within parentheses.

[b] The average standard error was 64.0 milliseconds ranging from 49.8 to 77.8.

[c] The average standard error was 68.1 milliseconds, ranging from 56.7 to 81.9.

500-Hz tone and blank tape were spliced onto the end of each fragment.

Phrases. Phrases which were consistent with the meaning of one of the clauses of the sentences used for positive trials were obtained by administering a questionnaire to students in a psycholinguistics class at Montclair State College. The students were shown the 19 intact positive sentences as they appeared on one of the lists. In each sentence the probed clause was underlined. For some sentences the underlined clause was initial main, for some, the initial subordinate, and so on. The students were asked to generate a two- to four-word verb–object phrase which was related to or consistent with the meaning of the underlined clause. They were instructed to produce phrases that did not repeat any of the content words in the sentence. From the pool of verb–object phrases obtained in this manner, the phrase generated most frequently for each sentence was selected for use in the experiment; for sentences (1)–(4), for example, the phrase was *finding employment.* For negative trials verb–object phrases judged to be totally unrelated to the meaning of either clause were selected.

Subjects. Sixteen undergraduate volunteers (eight males) at Montclair State College served in the experiment. All were right-handed native speakers of English.

Results

The error rate for trials in which the phrase was consistent with one of the clauses was 4.3%, while the error rate for trials in which the phrase was not consistent with either of the clauses was 7.8%. The percentage of errors and mean response times for correct responses in different clause types and positions are shown in Table 2. To simplify the statistical analysis of response time data the response times for positive trials on which errors were made were replaced by the mean response time for correct responses in the appropriate clause type × clause position × lexical content cell. For negative trials, error response times were replaced by the means for correct responses in the appropriate clause type × clause position cell.

Positive trials. The initial statistical analysis of response times for positive trials used analysis of variance with clause type, clause position, word order, block, and lists as variables, the first four treated as within-subject variables. Since each subject was tested on a given set of words with different combinations of independent variables, words by treatments were nested within subjects. The analysis of variance therefore treats both subjects and words by treatments as random effects, and the statistical tests are general-

izable to the larger population of subjects and materials (see Clark, 1973, p. 348).

The means in Table 2 suggest that response times on positive trials were shorter when main clauses were interrupted. This conclusion was supported by the analysis of variance, $F(1, 16) = 4.58$, $p < .05$. The clause type x clause position interaction fell short of significance, $F(1, 16) = 3.14$, $p < .10$, and no other interactions approached significance, though there was a large effect of block, $F(1, 16) = 13.9$, $p < .01$, with the mean response time of block 2, 1169 milliseconds, much faster than that of block 1, 1302 milliseconds. While there was a large practice effect, the major variable affecting overall response times was the type of interrupted clause—subjects had much better access to the meaning of main clauses.

The relative effects of subordination did vary with conjunctions, however. Table 3 shows the difference in mean response time between subordinate and main clauses ($\overline{RT}_{\text{subordinate}} - \overline{RT}_{\text{main}}$) for fragments using different conjunctions. The effect of subordination was opposite in initial *if* and *though* fragments: Response times were 136 milliseconds faster on subordinate clauses in *if* fragments, but 340 milliseconds slower on subordinate clauses in *though* fragments. Performance on initial clause fragments introduced by *since*, *when*, and *while* fell between these extremes and followed the causal–temporal dimension illustrated in Table 1. On final clause fragments there was also wide variation depending on the conjunction introducing the final clause, but, in this case, response times were 295 milliseconds slower on *if* clauses than on the corresponding main clauses and response times for *though* clauses and main clauses were about equal (a 21-millisecond difference).

TABLE 3

EFFECTS OF CLAUSE TYPE ON JUDGMENTS OF CONSISTENCY OF MEANING IN FRAGMENTS WITH VARIOUS CONJUNCTIONS ($\overline{RT}_S - \overline{RT}_M$)[a]

	Initial clause	Final clause
If	−136	+295
Since	+9	+143
When	+19	+117
While	+68	+169
Though	+340	+21

[a] Note: The critical difference ($p < .05$, $df = 216$) in (subordinate–main) between conjunctions is 192. In initial clauses, relative response time for *though* clauses differs from all other subordinate clauses, and *while* differs from *if*.

Negative trials. For negative trials, Table 2 shows that response times were faster for main clauses when the initial clause was interrupted, but slightly slower for main clauses when the final clause was interrupted. Response times for negative trials were examined by analysis of variance with clause type, clause position, and blocks as variables. This analysis showed a trend toward an interaction between clause type and clause position, $F'(1, 151) = 3.48$, $p < .10$. There were no other significant main effects or interactions in the analysis by subjects or by sets of words. A comparison of main and subordinate response times for initial clauses indicated a marginal effect, $F'(1, 121) = 2.92$, $p < .10$. A similar comparison for final clauses showed no difference between response times to main and subordinate clauses, $F' < 1$. Subjects were faster at deciding that a phrase was inconsistent with the meaning of an initial main clause than they were at doing so for initial subordinate clauses. However, they did not differ in the speed with which they decided that a phrase was inconsistent with the meaning of the sentence when final main or subordinate clause was interrupted.

Discussion

Overall, on-line accessibility to meaning was faster in main clauses than in subordinate clauses. While this result favors the structural hypothesis, the considerable variation in the size and even direction of subordinate–main differences across fragments using different conjunctions casts doubt on both the struc-

tural and presuppositional hypotheses as explanations for the data. The size of the subordinate–main differences in initial clause position, did, however, follow the causal–temporal dimension described in the introduction. The data suggest that initial clauses that are more explicitly marked as stating a cause for the event in the following clause are more directly interpreted and that initial *though* clauses, which explicitly state that the event in the initial clause is *not* a cause for the following event, are less directly interpreted. An initial *though* clause may be held in superficial form so that it can be interpreted in light of the meaning of the following main clause. The relative effects of *if* and *though* clauses in final clause position, however, were reversed. We return to this reversal in performance after considering whether the causal–temporal dimension is also related to the listener's accessibility to the literal form of a clause.

Experiment II

In the second experiment we presented to subjects the same lists used in Experiment I, but after each fragment we presented a probe word rather than a verb–object phrase. The subject's task was to say as quickly as possible whether or not the probe word was mentioned in the fragment. The critical variable was whether the target word occurred relatively early or relatively late in the interrupted clause. A notable aspect of our design was that the same word served as the target both early and late; such a design controls for the effects of semantic and grammatical characteristics of the target words.

The central problem was whether the listener searches his representation of a clause differently depending on whether the representation is in relatively semantic form vs. in relatively literal form. We suggest that semantic representations are searched by an essentially parallel process that is relatively insensitive to literal form, that is, word order. That such a process operates on propositional representations is indirectly suggested, though not demanded by, several previous studies (Green, 1975; Kennedy & Wilkes, 1969, 1970). On the other hand, we suggest that literal representations are searched by a word-by-word, left-to-right scan that is sensitive to word order. Evidence for item-by-item scans has been found in previous studies which require retention of order information (Sternberg, 1967; Kennedy & Wilkes, 1969, 1970; see also Green, 1975).

This analysis suggests that target position effects should be greater for those clauses that produced rather slow accessibility to meaning in Experiment I. That is, target words occurring late in a subordinate clause should take longer to classify than target words occurring early in a subordinate clause, but there should be little difference between early and late targets in main clauses. Furthermore, the difference in response times between late targets and early targets in initial subordinate clauses, relative to main clauses, should decrease as the subordinate clause states more explicitly that it is a cause for the event in the main clause. This prediction follows from the results of Experiment I, that the relative advantage of main clauses over subordinate clauses in accessibility to meaning decreased with the explicitness with which a subordinate clause states a causal relation.

Method

Procedure. The subjects were tested individually, one subject for each list. All subjects heard the sentences and probe words in the right ear. A tone signaled the end of the sentence fragment and activated a millisecond timer which was stopped by the subject's vocal response. Subjects were instructed to respond as quickly as possible to the word occurring after the tone, saying "yes" if the probe had occurred in the fragment and "no" if it had not. In order to induce comprehension of the fragments, subjects were instructed to generate a sentence which paraphrased the sentence fragment after they had responded to the

probe. This requirement was effective in that all paraphrases were judged to be accurate.

Materials. The tape recordings used in Experiment I were modified for a word-probe experiment. For each fragment a monosyllabic target word was selected. For positive trials, which consisted of the same set of fragments used in positive trials in Experiment I, the target was the moveable word. Target words classified as "early" in the clause occurred six to eight words from the end of the clause with a mean of seven, while "late" targets occurred three to five words from the end, with a mean of four. The early and late positions of a particular target word were separated by two to five words. The grammatical class of the target was distributed evenly across nouns, verbs, adverbs, and particles in positive trials as well as in negative and practice trials. The target word for negative trials did not occur in the fragments, nor was it similar in sound or meaning to any word occurring in the fragment. For half of the practice fragments a word appearing in the fragment was selected as a target.

Tape recordings of the 34 probe words were made and copies of these were spliced onto the tape containing the fragments. The probe was placed so that it began 333 milliseconds after the end of the tone.

Subjects. Sixteen undergraduates (eight males) at Montclair State College were paid $2.00 for their participation. They were right-handed native speakers of English.

Results

The error rate was 0.4% when the target was in the sentence fragment and 3.1% when it was not. To simplify the statistical analysis, response times for errors were replaced in a fashion similar to that used in Experiment I.

Positive trials. For positive trials overall, there was no response time difference between main and subordinate clauses, $F(1, 16) = 1.93$, $p > .05$, nor was there a difference between initial and final clauses, $F(1, 16) < 1$, as suggested by Table 4. That is, the average accessibility of the actual words did not differ by clause type or by clause position. The overall mean response times by clause type, clause position, and target position, however, did vary. Target position had its strongest effects in subordinate clauses and its weakest effect in initial main clauses. Target position had opposite effects in initial and final subordinate clauses and larger effects in final main clauses than in initial main clauses. These conclusions were supported by a clause type x clause position x target position interaction, $F(1, 16) = 9.44$, $p < .01$. These variables together did not interact with list or block. Response times were slower for late targets than for early targets in initial subordinate clauses, $F(1, 16) = 6.35$, $p < .05$, and in final

TABLE 4

MEAN RESPONSE TIMES FOR RECOGNITION OF EARLY AND LATE TARGET WORDS[a]

	Initial clause				Final clause			
	Main		Subordinate		Main		Subordinate	
	Early	Late	Early	Late	Early	Late	Early	Late
Positive[b]	1098	1125	1085	1181	1117	1207	1157	1057
$\bar{X}_{\text{positive}}$	1112(0)		1134(1.6)		1162(0)		1107(0)	
Negative[c]	1157(4.2)		1280(2.1)		1352(2.1)		1342(4.2)	

[a] Response times are expressed in milliseconds. The percentage of errors is indicated within parentheses.

[b] The average standard error was 53.3 milliseconds, ranging from 33.8 to 65.3.

[c] The average standard error was 46.6 milliseconds, ranging from 34.9 to 64.6.

main clauses, $F(1, 16) = 5.58, p < .05$, but not in initial main clauses, $F(1, 16) < 1$, nor in final subordinate clauses, which showed a large recency effect, $F(1, 16) = 6.89, p < .05$. The location of the target word had large effects on response time in all clauses except initial main clauses, where the position effects were negligible.

Table 5 presents the target position effects for fragments using different conjunctions. The table shows the effects of target position in subordinate clauses relative to its effect in the corresponding main clauses. That is, for each fragment we calculated the difference ($\overline{RT}_{late} - \overline{RT}_{early}$) for the subordinate clause and subtracted from that the difference ($\overline{RT}_{late} - \overline{RT}_{early}$) for the main clause. The resulting score provides some control for differences between fragments in within-clause lexical items and structural complexity. The $(L–E)_S - (L–E)_M$ score is highly positive when response times are slower to late targets than to early targets in a subordinate clause but faster to late targets than to early targets in the corresponding main clause; a highly positive $(L–E)_S - (L–E)_M$ score indicates a "primacy" effect in subordinate clauses relative to main clauses.

The relative target position effects varied widely depending on the conjunction in the fragment. In initial clause position the relative primacy effects were strongest in *though* clauses and they became weaker as the subordinate clause became more causal. The primacy effect was actually weaker in initial *if* clauses as compared to the corresponding main clauses. The relative primacy effects for other initial subordinate clauses fell between these extremes and followed the causal–temporal dimension of Table 1. In final clause position the ordering of relative primacy effects was roughly opposite that in initial clause position: Subjects were most sensitive to the literal form of final *if* clauses and (nearly) least sensitive to the literal form of final *though* clauses.

TABLE 5

EFFECTS OF CLAUSE TYPE ON WORD RECOGNITION IN SENTENCES WITH VARIOUS CONJUNCTIONS: $(\overline{RT}_L - \overline{RT}_E)_S - (\overline{RT}_L - \overline{RT}_E)_M$

	Initial clause	Final clause
If	−159	+86
Since	−106	−329
When	−67	−125
While	+77	−34
Though	+399	−267

[a] Note: The critical difference ($p < .05$, $df = 216$) in derived scores between conjunctions is 143. In initial clauses relative target position effects in *though* and *while* differ from all other subordinate clauses.

Negative trials. Those clause types which showed large overall effects of target position also showed a large difference between response times to positive and negative trials (see Table 4). The differences between positive and negative trials were assessed in a between-subject and -lexical content analysis of variance with trial type, clause type, clause position, block, and list as variables. The type of trial interacted with the type and position of the interrupted clause, $F(1, 383) = 4.17$, $p < .05$. The slower response times for negative trials than for positive trials in initial subordinate clauses, $t(383) = 2.83$, $p < .01$, final subordinate clauses, $t(383) = 4.56$, $p < .01$, and final main clauses, $t(383) = 3.69$, $p < .01$, suggest that subjects examined every word of these fragments before responding only in the case of negative trials. On the other hand, the fact that response times for negative and positive trials did not differ in initial main clauses, $t(383) = 0.87$, $p > .10$, suggests either that subjects did not compare the probe with every word individually or that they did do so for both positive and negative trials. These comparisons of positive and negative trials are only suggestive however, since different sets of words were used in the two types of trials.

Discussion

Overall, the target position effects were much smaller in initial main clauses than in other types of clauses. This suggests that the

literal form of an initial main clause is more quickly lost in immediate processing, supporting a structural or presuppositional hypothesis. However, the target position effects were strongly influenced by the particular conjunction contained in the fragment. Among initial clauses, primacy effects in subordinate clauses were weakest in *if* clauses, but these effects became progressively stronger in *since*, *while*, and *though* clauses. These results indicate that on-line accessibility to superficial form in initial clauses increases in the order: *if* clause, *since* clause, *when* clause, *while* clause, and *though* clause.

The results by conjunctions were quite similar in the two experiments. In initial clauses, the size of the subordinate–main differences were ordered identically in the two experiments; relative accessibility to meaning was poorest in *though* clauses but relative sensitivity to literal form was best in *though* clauses. The results for final clauses were roughly opposite those for initial clauses in both experiments. The parallel results for conjunctions within clause positions strongly suggest that the underlying factor affecting performance is not the structural or presuppositional properties of the clauses, but instead, is the meanings of the conjunctions and the kinds of organizing strategies they elicit.

The two experiments also gave similar results across the 16 sentences from which the positive fragments were derived. For each of the 16 sentences, we calculated a total (subordinate–main) score as described previously, but now summed over initial and final clauses. These scores were highly correlated, $r_s = +.57$, $t(14) = 2.59$, $p < .05$. This correlation indicates that those sentences that produced slower synonymy-judgment times in subordinate clauses relative to main clauses also produced greater sensitivity to superficial form in subordinate clauses relative to main clauses. It follows that the listener's accessibility to semantic form is related to his word recognition processes.

General Discussion

The two experiments converge on the following conclusion: Listeners are sensitive to the possible semantic relations between clauses that are cued by conjunctions while they hear a two-clause sentence and modify their comprehension processes in terms of these semantic relations. While the overall performance differences between main and subordinate clauses support structural and presuppositional hypotheses about clausal processing differences, the variations in performance within different subordinate clauses do not support either of these hypotheses. Instead, the performance differences followed the causal–temporal dimension described in Table 1.

Initial subordinate clauses that more explicitly signaled a causal relation to the following clause were more deeply processed. Of the clauses studied here, the *if* clause is most explicit in indicating a causal relation: it describes a generic set of conditions which either cause the main clause event or constitute evidence for it. *Since* has a more specific causal sense than *if*, but it may also have the temporal sense of *after*. *When* may have, by inference, the causal or temporal meanings of *since*, but it more directly indicates an event occurring at the same time as the event in the main clause. *While* may have the temporal co-occurrence meaning of *when*, but it may also have an adversative reading of "contrary to the fact that the event in this clause would ordinarily cause, or lead one to expect, a certain event, some event other than the expected event has occurred." This contrary-to-expectation relation is strongest in *though*, where it is an explicit denial of the relation indicated by *if*.

Our results for initial clauses indicate that, relative to main clauses, more explicitly causal subordinate clauses are processed more deeply during listening, and less explicitly causal subordinate clauses are held in more literal form during listening. For example, listeners had

easy access to the meaning of initial *if* clauses. An initial *if* clause is processed deeply as it is heard because it is important for evaluating the event in the final clause: An *if* clause describes the conditions in which the event in the following clause will occur. On the other hand, initial *though* clauses, indicating a denial of a causal relation, were held in very superficial form. This may be the case because, at the time the listener hears the initial *though* clause, he cannot know which cause–effect relation the speaker is denying. For example, on hearing "Though Harry ate the apple . . .," the listener knows that the speaker believes that "Harry ate an apple" would normally be a cause for some event, or evidence for some belief, but the listener does not know what cause–effect or evidence–belief relationship the speaker has in mind. On hearing the main clause, ". . . he got stick," the listener now knows that the speaker has denied the cause–effect relation of "eating an apple causes one to be healthy." But on hearing the main clause, ". . . he wanted a steak," the listener knows that the speaker has denied the evidence–belief relation of "X ate an apple is evidence that X wanted to eat an apple." Listeners may hold initial *though* clauses in relatively superficial form until they have interpreted the main clause so that they can determine which cause-expected effect relation has not been fulfilled.

The results for final clauses showed a strong reversal from the pattern found in initial clauses. In final clause position, the meanings of *though* clauses and of the corresponding main clauses were about equally accessible, but the meanings of *if* clauses were much less accessible than the meanings of the corresponding main clauses. A similar shift occurred in relative sensitivity to literal form in word recognition. These shifts must be taken seriously, for the relative ordering of differences by conjunctions in final clause position were highly correlated ($r_s = 0.7$) across the two experiments. The results therefore suggest that the listener does not process on-line for meaning in a final *if* clause as much as he does for other clauses. This may be the case because the *if* clause sets up a generic condition on the previously heard main clause. As such, the listener must interpret the final *if* clause "as a whole" and perhaps reorganize the events of the sentence into their proper cause–effect relationship. The listener may readily interpret a final *though* clause because he can determine on-line the specific cause–effect relation that is being denied, since he already knows the "unexpected effect" stated in the previous clause.

The experiments reported here show that the semantic relations between clauses modify the on-line processing and organization of clauses. Although our interpretation of the data accounts for the most prominent variations and regularities in the data, the broader significance of these experiments is that they suggest that the semantic relations between clauses may exert a larger effect on immediate processing than had been considered previously. These experiments lead to the further possibility that the semantic relations existing between sentences in discourse may modify the ongoing processing of discourse.

APPENDIX

The sentences from which positive fragments were derived are presented below. Target words are underlined.

1a. Though the telephone bills were much higher than usual, I liked calling *up* my aunt each night at nine.
b. . . . I liked calling my aunt *up* each night at nine.
2a. While the rest of the furniture can remain where it is, the *large* couch or small chair must be moved.
b. . . . the small couch or *large* chair must be moved.
3a. If the students do poorly on the economics test, Miss Jones lets *out* the whole class too late for gym.
b. . . . Miss Jones lets the whole class *out* too late for gym.
4a. While the brand new field is not used at all in the spring, teams play *there* a lot at the end of fall.
b. . . . teams play a lot *there* at the end of fall.

5a. Since the guests are waiting to be seated for dinner, Tom has *poured* the red wine and served the iced tea.
b. . . . Tom has served the red wine and *poured* the iced tea.
6a. When the hardware store was having the last day of its sale, Jim bought some *nails*, some long boards, and light bulbs.
b. . . . Jim bought some boards, some long *nails*, and light bulbs.
7a. Though there is little danger of a major depression, good jobs are *now* quite scarce in most large states.
b. . . . good jobs are quite scarce *now* in most large states.
8a. Since Linda carried out the garbage and mowed the lawn, Bill *swept*, cleaned, and mopped the floor of the porch.
b. . . . Bill cleaned, mopped, and *swept* the floor of the porch.
9a. If the streets of the city get very congested, the trains *miss* their stops, run late, and break down.
b. . . . the trains run late, *miss* their stops, and break down.
10a. Since Ann will leave to do the weekly grocery shopping, Pete will *soon* come home from his job at school.
b. . . . Pete will come home *soon* from his job at school.
11a. Though we had not yet decided on who would pay the bill, the *beer*, the coke, and the milk had been packed.
b. . . . the coke, the *beer*, and the milk had been packed.
12a. When the chief supervisor walked into the office, Jack turned *off* the game and went back to work.
b. . . . Jack turned the game *off* and went back to work.
13a. While no work needed to be done in the apartment, Bob did put *down* some new tiles in the hall.
b. . . . Bob did put some new tiles *down* in the hall.
14a. When the circus starts to attract a lot of customers, the *clowns* and the trained bear are fun to watch.
b. . . . the trained bear and the *clowns* are fun to watch.
15a. If government assistance to the poor will increase, the *high* food costs will stay as they are now.
b. . . . the food costs will stay *high* as they are now.
16a. While the butler had little to do but stand around, the French chef *boiled* eggs, fried ham, and sliced bread.
b. . . . the French chef fried ham, *boiled* eggs, and sliced bread.

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(Received November 17, 1977)