XIV. LINGUISTICS

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A. USING TIME-COMPRESSED SPEECH TO MEASURE THE EFFECTS OF VERB COMPLEXITY

Martin Chodorow

There is a considerable amount of evidence (reviewed by Aaronson[1]) to support the following kind of model for the processing of time-compressed speech: When one listens to a time-compressed sentence, the signal is initially placed in a very short-term auditory buffer. In order to comprehend and save the message, it must be "actively processed." At high rates of presentation, active processing cannot handle the input as rapidly as it enters sensory storage. Therefore, at the termination of the signal, some processing remains to be completed. It is the act of finishing the processing that may interfere with or be subject to interference from subsequent material. Listeners have difficulty with long passages of compressed speech because the presentation of each sentence interferes with the processing of adjacent sentences. The experiment reported here was designed to test this model generally and to determine specifically whether time-compressed speech can be used to measure the active processing requirements of various syntactic structural types.

1. Testing the Model

A modified version of the paradigm used by Savin and Perchonock[2] was employed in testing the model. They played recorded sentences, each followed by an eight-word list, with a 5 s silent interval between the end of the sentence and the beginning of the list. Subjects were asked to repeat the sentence and as many words from the list as they could. The words of the list fell into 8 categories which were always presented in the same order. The five members of each category were presented to the subjects before the experiment began.

For the present experiment, the Savin and Perchonock technique was modified in the following ways: (i) Rate of presentation of the test sentences was either normal (N) or compressed (C) to twice the normal rate. Recorded sentences were compressed by a program written by A. W. F. Huggins and run on a PDP-9 digital computer. The program performs two basic operations: first, it marks off segments to be deleted, and then it deletes the segments, abutting the remaining portions of the waveform. This particular program may be termed "pitch synchronous," for it contains algorithms that are designed to mark off glottal cycles. The experimental sentences were compressed to 50% of their original duration by deleting every other segment and abutting the remaining portions. The mean rate of presentation in the normal condition was 3.4 words (4.8 syllables) per second. (ii) The interval between the end of the sentence and the beginning of the list was shortened considerably and was manipulated as an independent variable. (iii) Subjects were required to paraphrase the sentence before recalling the list. They were instructed to give their first priority to understanding the test sentence, and were told that their list performance would not be scored unless they provided an adequate paraphrase of the test sentence.

Each sentence was preceded by a warning, "Get ready to listen to the sentence that follows." The warning was presented at the same rate as the test sentence, which followed after a one-second delay. The eight words of the list were presented one every 3/4 second. Average duration for each list item was .480 second. The entire sequence of events was as follows: (i) warning, (ii) one-second interval, (iii) test sentence (either (N) or (C)), (iv) variable interval, (v) eight-word list, (vi) subject paraphrases sentence, (vii) subject recalls word list. Subjects were given 6 practice sequences before beginning the experiment.

Four conditions of presentation were used. The standard condition paired a normal presentation rate for the sentence with a 750-ms interval before the word list (Normal + 750). In the other three conditions the compressed rate was employed. One of these (Compressed $+750 + t_N/2$) used an interval equal to 750 ms plus one-half the duration of the normal sentence, so that the total time from the beginning of the sentence to the beginning of the list was the same as in the standard condition. (Compressed $+750 + t_N/2$)

thus served as a control condition; a difference between it and the standard condition would be attributable to the rate factor. The other two conditions paired the compressed rate with 750 ms and 200 ms. It was hypothesized that displaced sentence processing would be completed within 750 ms but not within 200 ms. Poorer performance on the word list (fewer items remembered) was taken to be an indication of greater interference produced by sentence processing. Therefore word recall for (Compressed + 200) should be inferior to that for (Compressed + 750).

2. Measuring Structural Processing Requirements

The sentences used in the experiment (see Appendix) form a subset of those used by Holmes and Forster[3] in a rapid serial visual presentation (RSVP) study. Twenty ten-word sentences were selected for use, with four sentences representing each of 5 structural types: single-clause sentence with simple verb (SS) (e.g., Sally injured her left elbow during a game of squash); single-clause sentence with noun-phrase complement verb (SNP) (The doctors announced their strong support for the health scheme); single-clause sentence with verb-phrase complement verb (SVP) (John's brother trained all the animals for the local circus); noun-phrase complement sentence (CNP) (Susan realized that her brother had bought several new records); verb-phrase complement sentence (CVP) (The angry officials urged the man to complete the form).

The Holmes and Forster study was designed to assess the structural processing requirements of these sentence types. Based on the number of words that subjects could report from the RSVP sentences, the experimenters concluded that (i) one-clause sentences containing complement verbs are more difficult than one-clause sentences with simple verbs, (ii) verb-phrase complement sentences are less difficult than noun-phrase complement sentences, and (iii) in general, complement sentences are not more difficult than one-clause sentences.

Four test sequences, corresponding to the four presentation conditions, were prepared for each of 20 experimental sentences. Four tapes were constructed by selecting one test sequence for each sentence. For each structural type, on every tape one sentence was presented under each of the four conditions. The sentences were arranged in blocks of five, with every block containing one of each structural type and at least one of each presentation condition. Thirty-two subjects (8 per tape) were paid for their participation in the 45 min experiment.

3. Results

a. General Model

An analysis of variance was performed for a three-factor experiment, with one random between-subjects factor: tape (4); and two fixed within-subjects factors:

presentation condition ((Normal +750), (Compressed +200), (Compressed +750), (Compressed +750 + $t_N/2$)) and structural type (SS, SNP, SVP, CNP, CVP). The results are shown in Table XIV-1. The main effects for tape $(F_{(3,28)}=.115)$ and structural

Table XIV-1. Experimental results: Mean number of words recalled.

	SS	SNP	SVP	CNP	CVP	Mean across Types	Contrasts		
							c_1	c_2	c_3*
Normal + 750	4.75	4.47	4.41	4.56	4.47	4.53	1	1	1
Compressed + 750 + $t_N/2$	4.59	4.19	4.69	4.63	4.41	4.50	-1	1	1
Compressed + 750	4.22	4.59	4.66	4.31	4.25	4.41	0	-2	1
Compressed + 200	4.41	4.09	3.78	4.69	3.63	4.12	0	0	-3
Mean across Conditions	4.49	4.34	4.38	4.55	4.19				

Contrasts

	Compressed + 750					Compressed + 200				
	SS	SNP	SVP	CNP	CVP	SS	SNP	SVP	CNP	CVP
*c_1	0	1	1	0	0	0	-1	-1	0	0
c_2	1	0	0	0	0	-1	0	0	0	0
*c_3	0	0	0	0	0	0	0	0	1	-1

*Significant at or below the .05 level.

type $(F_{(4, 12)}=2.119)$ failed to be significant. But the main effect for presentation was marginally significant $(F_{(3,9)}=3.297, p<.08)$. Orthogonal contrasts indicated that (Normal +750) and (Compressed +750 + $t_N/2$) were not significantly different $(F_{(1,9)}=.046)$; nor were these two different from (Compressed +750) $(F_{(1,9)}=.382)$. The difference between (Compressed +200) and the other three conditions was very significant $(F_{(1,9)} = 9.079, p<.025)$.

b. Structural Variable

The interaction between presentation condition and structural type was not significant $(F_{(12,36)}=.679)$. Three orthogonal contrasts were used to test the hypotheses concerning the interaction between structural type and processing interference.
(i) For the single-clause sentences with complement verbs, performance under the

(Compressed + 200) condition was inferior to that for (Compressed + 750) $(F_{(1,36)} = 9.033$, $p < .005$); the difference between (Compressed + 200) and (Compressed + 750) was not significant for single-clause sentences with simple verbs $(F_{(1,36)} = .168)$. (ii) Performance was significantly different under condition (Compressed + 200) for the two types of complement sentences $(F_{(1,36)} = 5.398, p < .05)$. This difference was opposite in sign to that predicted, i.e., CVP was found to be inferior to CNP. (iii) Overall, the difference between complement sentences and single-clause sentences under condition (Compressed + 200) was negligible. The mean for single-clause sentences was 4.37 words recalled; for complement sentences, it was 4.40 words. The three-way interaction of tape X presentation condition X structural type was significant $(F_{(36,336)} = 2.371$, $p < .01)$. Three of the four tape groups displayed the pattern of differences revealed by the orthogonal contrasts. One of the groups failed to produce any of the differences.

4. Discussion

a. General Model

The results for the presentation factor are consistent with the general picture of sentence comprehension. It is difficult to account for the effects of this factor by appealing to a mechanism such as rehearsal. The two short intervals, 750 ms and 200 ms, hardly provide sufficient time for rehearsal of a ten-word sentence. One might argue that the difference in performance does not reflect active processing, but rather some difference in the quality of the immediate sensory copy produced in the (Compressed + 200) condition. According to this view, for the compressed conditions having the 750 ms and 200 ms intervals, the subject actively processes the copy after the presentation of the list. If the copy is of poorer quality because of the shorter post-sentence interval (200 ms), the subject must devote more of his resources to processing it actively, which results in poorer list performance. This account is unsatisfactory because Treisman[4] has demonstrated a very rapid decay for unprocessed verbal material. Therefore it seems unlikely that a copy could be maintained for the 6 s duration of the word list.

b. Structural Variable

The experiment provides evidence that verb-phrase complement sentences are as complex as single-clause sentences with complement verbs, but noun-phrase complement sentences are less complex. This difference, together with the difference between single-clause sentences with simple and complement verbs, may be the result of temporary, on-line structural ambiguity. When the listener encounters a complement verb, he is unable to determine immediately whether it will be followed by a direct object or a complement construction. This kind of structural ambiguity remains unresolved in SNP and SVP in some instances until the end of the sentence is reached. For example,

the string <u>The doctors announced their strong support for the health scheme</u> may be the beginning of the CNP <u>The doctors announced their strong support for the health scheme could no longer be counted on by the legislators.</u> This problem does not arise for SS because subcategorization information for the verb specifies an unambiguous environment. Complement sentences provide the listener with structural ambiguity, but it is resolved much sooner than in the single-clause sentences containing complement verbs. All noun-phrase complement sentences contained a complementizer immediately following the main verb. In the verb-phrase complement sentences, disambiguation was not provided as rapidly because the complementizer <u>to</u> occurs after the object noun phrase, and is therefore separated from the main verb by several words. If this kind of structural ambiguity is a source of complexity, then the longer this ambiguity persists, the more complex the sentence should be. Accordingly, SS and CNP should be least complex, CVP should be of intermediate complexity, and SNP and SVP should be most complex. The data support this ordering, except for the prediction of intermediate complexity for CVP; there was no indication that CVP was any less complex than the single-clause sentences with complement verbs.

<center>Appendix</center>

<center>Sentences Used in Experiment</center>

<u>Single-Clause Sentences with Simple Verbs</u>

Alan left a large pile of books in the library.
Sally injured her left elbow during a game of squash.
The cleaners couldn't empty all the ashtrays in the building.
Many people attended the seminar on the government's foreign policy.

<u>Single-Clause Sentences with Noun-Phrase Complement Verbs</u>

The actors didn't like the plot of the new play.
The doctors announced their strong support for the health scheme.
Your cousin doubted the truth of the rumors about Jim.
The judge decided the case in favor of your daughter.

<u>Single-Clause Sentences with Verb-Phrase Complement Verbs</u>

The prime minister inspired the members with a brilliant speech.
Betty relied on her friends for advice on financial problems.
Bob hired a group of young men for the job.
John's brother trained all the animals for the local circus.

Noun-Phrase Complement Sentences

Susan realized that her brother had bought several new records.

The children believed that their mother was in serious trouble.

The lawyer didn't think that his client was a thief.

Two strange men said that the elevator wasn't working properly.

Verb-Phrase Complement Sentences

The angry officials urged the man to complete the form.

Jim ordered his young brother to wash the dirty dishes.

Several people forced the foreign students to leave the hotel.

The author didn't encourage anyone to read his early books.

References

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B. USING TIME-COMPRESSED SPEECH TO MEASURE THE EFFECTS OF AMBIGUITY

Martin Chodorow

A general model for the processing of time-compressed speech was sketched in Section XIV-A. The following experiment was designed to provide an additional test of the model and to determine specifically whether time-compressed speech can be used to measure the active processing requirements of lexical and structural ambiguity.

1. Testing the Model

The basic procedure reported in Section XIV-A was also used in the present study, but with the following differences in sentence presentation:

The four conditions of presentation used in the experiment employed two rates (Normal and 50% Compressed) with two intervals (750 ms and 200 ms). (Normal + 750) was considered a standard condition. (Compressed + 750) was included to provide sufficient

processing time after a compressed sentence. Once again, poorer performance on the word list (fewer items remembered) was taken to be an indication of greater interference produced by sentence processing. In the (Compressed + 200) condition, processing was predicted to interfere with the list. (Normal + 200) was included to test the possibility that inferior performance in the (Compressed + 200) condition was the result of the short interval alone. It is possible that rapid switching from sentence processing to list processing always impairs the latter. If this hypothesis is correct, then word-list performance under the (Normal + 200) condition should be inferior to that for (Normal + 750).

2. Measuring the Processing Requirements of Ambiguity

Considerable evidence supports the general conclusion that ambiguity increases the processing complexity of a sentence. In an underlying structural ambiguity each word in the sentence has but a single interpretation; however, at least one word has more than one possible syntactic role. For example, in the sentence Visiting relatives always bored the little boy very much, relatives may be either the subject or the object of the verb visit. In a lexically ambiguous sentence, at least one word has more than one possible interpretation, but each word has a unique syntactic role. For example, in the sentence The cleaner found the pipe under the bench today, pipe may refer either to a metal pipe or a pipe for smoking.

Foss and Jenkins[1] have used the phoneme monitor paradigm to assess the processing load immediately following a lexically ambiguous word in a sentence that provided either a neutral or a biased context for the ambiguity. Reaction times were compared with those obtained from sentences in which the ambiguous word was replaced by an unambiguous control word. The experimenters found that response latency was greater after the lexically ambiguous word, both for neutral and biased contexts. Foss and Jenkins cite these results to support a model of processing in which both interpretations of an ambiguous word are always activated when the word is encountered in the sentence. Foss[2] examined sentences that contained underlying structural ambiguities, as well as sentences that contained lexical ambiguities. He found an increased reaction time to monitor for a target phoneme following the two types of ambiguity. Lackner and Garrett[3] used a selective auditory attention paradigm to measure the influence of unattended biased contexts on the interpretation of attended ambiguous sentences. On the basis of subjects' paraphrases of the attended sentences, Lackner and Garrett concluded that the biased contexts were effective in influencing the subjects' interpretation of the ambiguity. They viewed these results as support for a parallel processing strategy in which the listener actively pursues both of the options of the ambiguity. Conrad[4] played recorded test sentences to her subjects and followed each by the immediate presentation of a word printed in colored ink. The subjects' task was to name the color of the ink in which the word was presented. Latency to respond was assumed to be an indication of the amount

of interference between the word and the color-naming response. Test sentences contained a lexically ambiguous word in a biased context. Conrad interprets the results of her experiment as supporting a model in which both readings of a lexically ambiguous word are activated when that word is encountered even if a prior biasing context is present. This activation can be measured for only a short time after the ambiguous item occurs in the sentence. Garrett and Holmes[5] have used a rapid serial visual presentation technique to present sentences containing lexically ambiguous words in neutral and biased contexts. In a comparison with control sentences, each containing an unambiguous word in the place of the ambiguous one, there was no difference in the total number of words recalled, but in both contexts the lexically ambiguous word was recalled less often than the control word. This result is consonant with the phoneme monitoring data, which suggests an increased processing load for lexical ambiguity.

If ambiguity increases processing load, then word-list recall in the compression paradigm should be poorer for ambiguous sentences than for controls when the rate is high and the interval is short. At normal rates, or when a long post-sentence interval follows a compressed presentation, processing ought to be completed before the beginning of the list, so that performance with ambiguous and control sentences should not differ.

For each of 16 experimental sentences (listed in the appendix), 8 test sequences were prepared to correspond to the four presentation conditions for each of the two versions (ambiguous and unambiguous). Eight tapes were constructed by selecting one test sequence for each sentence. For each type (Lexical and Structural), on each tape there was one ambiguous and one control sentence presented under each of the four presentation conditions. The order of the sentences was randomized. Thirty-two subjects were paid for their participation in the 40 min experiment.

3. Results

An analysis of variance was performed for a five-factor experiment, with one random between-subjects factor: tape (8); and 4 fixed within-subjects factors: rate (Normal vs Compressed), interval (750 ms vs 200 ms), type (Lexical vs Structural), and value of ambiguity (Ambiguous vs Unambiguous). (See Table XIV-2.) The main effect for type ($F_{(1,7)} = 9.215$, $p < .05$) was significant, as was the interaction between rate and interval ($F_{(1,7)} = 5.494$, $p < .06$). Tests of simple effects indicated that the difference between (Compressed + 750) and (Compressed + 200) was significant ($F_{(1,7)} = 5.990$, $p < .05$), but the difference between (Normal + 750) and (Normal + 200) was not significant ($F_{(1,7)} = 1.572$). The interaction between rate, interval, and type was marginal ($F_{(1,7)} = 3.615$, $p < .10$). Simple effects tests indicated that the difference between (Compressed + 750) and (Compressed + 200) was significant for the structural set of sentences ($F_{(1,7)} = 8.504$, $p < .05$), but not for the lexical set ($F_{(1,7)} = 1.538$).

Table XIV-2. Experimental results: Mean number of words recalled.

	Lexical Set				Structural Set				Mean Overall	Contrasts	
	Ambiguous	Control	Mean	Contrast	Ambiguous	Control	Mean	Contrast*		c_1	c_2*
Normal + 750	4.50	4.50	4.50	0	4.28	4.00	4.14	0	4.32	1	0
Normal + 200	4.44	4.59	4.52	0	4.38	4.63	4.50	0	4.51	−1	0
Compressed + 750	4.28	4.84	4.56	1	4.18	4.28	4.23	1	4.40	0	1
Compressed + 200	4.19	4.50	4.34	−1	3.78	3.66	3.72	−1	4.03	0	−1
Mean across Conditions	4.35	4.61			4.16	4.14					
Mean for Set		4.48				4.15					

*Significant at or below the .05 level.

4. Discussion

a. General Model

The hypotheses concerning the conditions of presentation were confirmed; (Compressed + 200) was inferior to (Compressed + 750), but there was no difference between (Normal + 750) and (Normal + 200). It is therefore possible to conclude that the decrement in performance for (Compressed + 200) was not the result of the short interval alone or of compression alone. The significant main effect for type (Lexical vs Structural) was the result of superior performance with the lexical set of sentences. The interaction between type, rate, and interval revealed that the interference effect for (Compressed + 200) was significant for the structural sentences but not for the lexical ones. The lexical sentences were less demanding in terms of processing, so that apparently even a 200 ms interval was sufficient for their completion.

b. Ambiguity Variable

The overall difference between ambiguous and unambiguous versions was not significant for condition (Compressed + 200). The pattern of results, both for structurally ambiguous sentences and for their controls, reflected the overall pattern of the rate X interval interaction. The lexical sentences behaved differently. The unambiguous ones were not affected by compression and the short interval. This is consonant with the view that processing of the lexical sentences was completed very rapidly. The ambiguous sentences produced decrements in list performance under both compressed conditions. This suggests an increased complexity that was not handled adequately even with the longer 750 ms interval. Processing of lexical ambiguity seems to be particularly sensitive to rate. Even a rather long post-sentence interval is insufficient to compensate for the increased complexity. Such a finding of rate sensitivity would not be inconsistent with the results of earlier studies which point to an immediate but short-term increase in processing load following lexical ambiguity. If it is true that lexical ambiguity must be handled immediately and resolved quickly, then increasing the rate of the input should adversely affect this on-line processing. If the processing cannot be postponed or displaced, additional time provided at the end of the sentence should prove to be of little assistance.

Appendix

Sentences Used in Experiment

Ambiguous
Control

Lexical Set

The driver took the $^{\text{right}}_{\text{left}}$ turn at the intersection.

The artist put the $^{\text{glasses}}_{\text{dishes}}$ on the table carefully.

The athletes met near the $^{\text{bank}}_{\text{bridge}}$ late yesterday evening.

They didn't want the $^{\text{commission}}_{\text{committee}}$ to be too small.

All the boys watched the $^{\text{coach}}_{\text{bus}}$ leave the depot.

The cleaner found the $^{\text{pipe}}_{\text{cigar}}$ under the bench today.

They knew that the large $^{\text{plant}}_{\text{forest}}$ would be sold.

The elderly farmer saw that the $^{\text{cane}}_{\text{wheat}}$ was damaged.

Structural Set

$^{\text{Visiting}}_{\text{Older}}$ relatives always bored the little boy very much.

All the people were surprised by the chancellor's $^{\text{selection}}_{\text{departure}}$.

The new mayor asked the police to $^{\text{stop}}_{\text{quit}}$ drinking.

The doorman hit the old fellow $^{\text{with the cane}}_{\text{on the head}}$.

Guides announced that the elephant was ready to $^{\text{lift}}_{\text{die}}$.

The little old lady wanted the chickens to $^{\text{eat}}_{\text{cackle}}$.

Billy $^{\text{helped}}_{\text{kicked}}$ his brother to get his father's attention.

The boy $^{\text{trained}}_{\text{sold}}$ his parrot to please his aunt.

References

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C. AN EXPERIMENTAL STUDY OF IMPLICATION AND NEGATION

Martin S. Chodorow

Karttunen has described a class of words that he has labeled "implicative verbs."[1] Part of the meaning of each of these verbs is the implication it holds for the truth value of its embedded complement. When affirmatively asserted, a verb such as remember, happen, manage, or condescend implies that its complement is true. When affirmatively asserted, a verb such as forget, fail, decline, or neglect implies that its complement is false. The former group of verbs will be referred to as positive implicative, and the latter as negative implicative. When negatively asserted, the implicational properties of these verbs are the opposite of their affirmative forms, so that a negatively asserted positive implicative verb implies that its complement is false, and a negatively asserted negative implicative verb implies that its complement is true. The four sentences given in Fig. XIV-1 illustrate these implicational properties.

If we let v represent the implicative verb and S represent its complement sentence,

	TYPE OF VERB	FORM OF ASSERTION
The robber succeeded in stealing the Crown jewels. IMPLICATION The robber stole the Crown jewels.	positive	affirmative
The robber didn't succeed in stealing the Crown jewels. IMPLICATION The robber didn't steal the Crown jewels.	positive	negative
The robber refrained from stealing the Crown jewels. IMPLICATION The robber didn't steal the Crown jewels.	negative	affirmative
The robber didn't refrain from stealing the Crown jewels. IMPLICATION The robber stole the Crown jewels.	negative	negative

Fig. XIV-1.   Implicational properties of positive and negative verbs.

then these relationships can be summarized as follows:

1. (a) $v(S) \supset S$ affirmatively asserted positive implicative

   (b) $\sim v(S) \supset \sim S$ negatively asserted positive implicative

2. (a) $v(S) \supset \sim S$ affirmatively asserted negative implicative

   (b) $\sim v(S) \supset S$ negatively asserted negative implicative

Karttunen[2] has suggested that an important linguistic generalization may be captured if all implicative verbs can be shown to have the same underlying implications. Such a generalization would take the form of a single set of implications which need only be stated once in the grammar of the language. If negative implicative verbs are assumed to be derived surface forms that are represented at some deeper level as IMPLICATIVE plus NEGATION, then the implications in 1(a) and 1(b) are adequate to account for the linguistic facts given in Fig. XIV-1. The surface verb fail is derived from NEG succeed, and therefore its implication is given by 1(b). Didn't fail must be derived from NEG NEG succeed, with some auxiliary rule allowing the introduction of double negation without altering the implication in 1(a). Givón[3] supports this general form of analysis and points out that, in addition to capturing a generalization about implications, it also explains why the members of positive-negative pairs, such as remember-forget and succeed-fail, share common presuppositions.

Support for the derivational view of negative implicatives comes from an experiment conducted by Just and Clark,[4] in which subjects were required to judge the truth of conclusions found in premise-conclusion constructions of the following sort:

3. If John $\genfrac{}{}{0pt}{}{\text{remembered}}{\text{forgot}}$ to let the dog out, then the dog is out(in).

The experimenters found that subjects took longer to deal with sentences containing the negative implicative verb forgot. Furthermore, reaction times were longer when true conclusions followed forgot premises than when false conclusions followed the same premises. This advantage of a FALSE response over a TRUE response is characteristic of negative sentences in various sorts of verification tasks.[5-8] It is primarily this FALSE-TRUE difference upon which Just and Clark[4] base their conclusion that when dealing with implication, listeners treat sentences containing negative implicative verbs as if they were negative sentences.

1. Testing the Derivational Model

To test both Just and Clark's conclusion and the derivational view, a preliminary experiment was designed so that negative implicative verbs could be compared to negatively asserted positive implicatives. Subjects were presented with sentence pairs: The first sentence of each pair contained a positive or negative implicative verb, in either the affirmative or negative assertion form, followed by a complement. The second

sentence of each pair was either an affirmative or negative version of the embedded complement of the first sentence expressed as a full surface form, i.e., with subject noun phrase and tensed verb. There were 4 first-sentence forms (two types of implication × two forms of assertion). Each of these was followed by two second-sentence forms (affirmative or negative). Subjects were asked to assume that the first sentence of each pair was true and to judge on that basis the truth of the second sentence. The design of the experiment is shown in Fig. XIV-2.
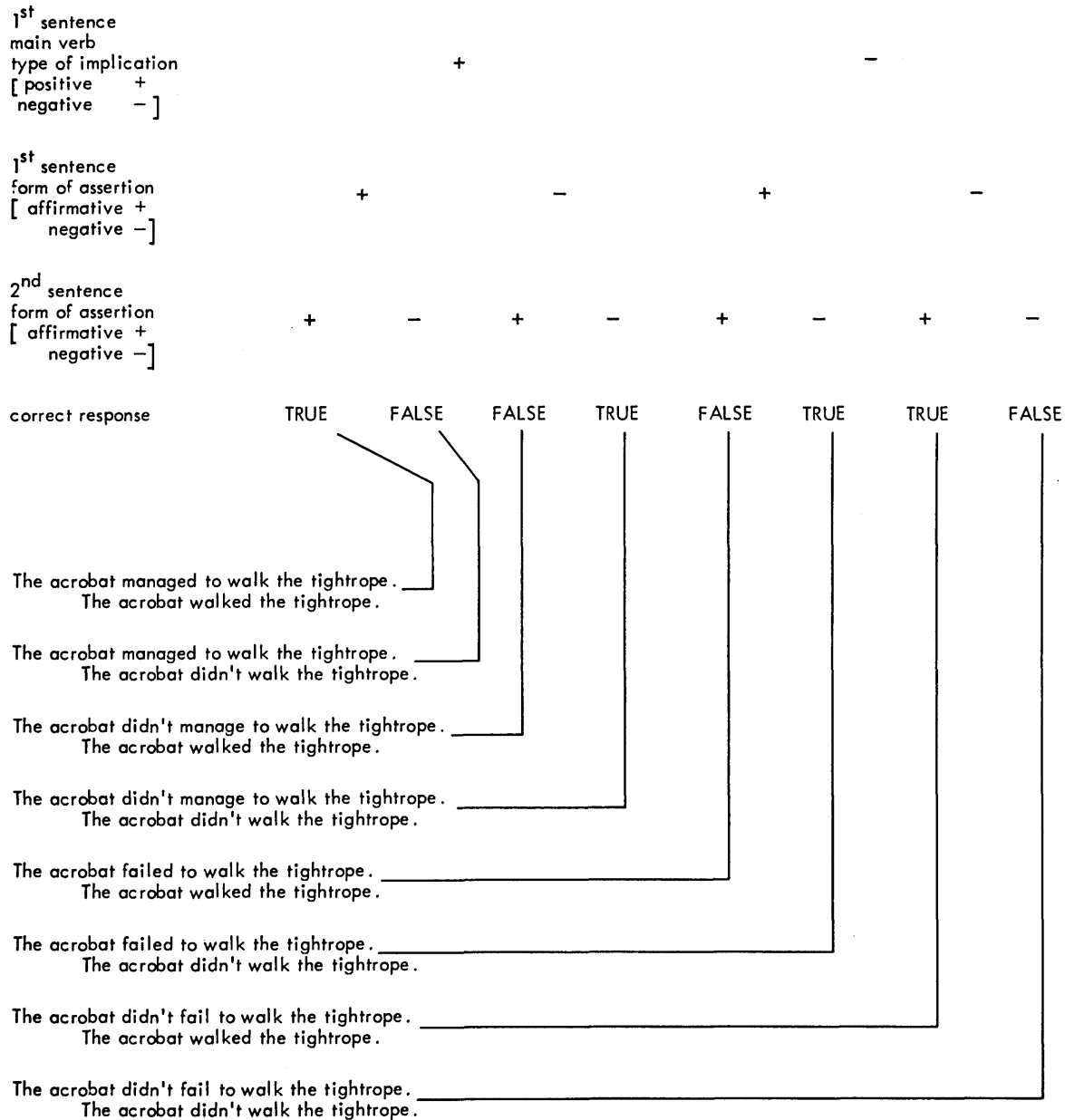
1st sentence
main verb
type of implication
[positive   +
  negative   −]   +   −

1st sentence
form of assertion
[affirmative +
    negative −]   +   −   +   −

2nd sentence
form of assertion
[affirmative +
    negative −]   +   −   +   −   +   −   +   −

correct response   TRUE FALSE FALSE TRUE FALSE TRUE TRUE FALSE

The acrobat managed to walk the tightrope.
    The acrobat walked the tightrope.

The acrobat managed to walk the tightrope.
    The acrobat didn't walk the tightrope.

The acrobat didn't manage to walk the tightrope.
    The acrobat walked the tightrope.

The acrobat didn't manage to walk the tightrope.
    The acrobat didn't walk the tightrope.

The acrobat failed to walk the tightrope.
    The acrobat walked the tightrope.

The acrobat failed to walk the tightrope.
    The acrobat didn't walk the tightrope.

The acrobat didn't fail to walk the tightrope.
    The acrobat walked the tightrope.

The acrobat didn't fail to walk the tightrope.
    The acrobat didn't walk the tightrope.

Fig. XIV-2.   Experimental design.

Three sentence frames were used in the experiment, with 8 pairs of sentences representing each frame (see appendix). Four additional filler pairs were constructed for each frame by using verbs that have some, but not all, of the characteristics of implicative verbs (see Karttunen,[1] necessary and sufficient verbs). The 36 sentence pairs (3 frames × 8 test-sentence pairs + 3 frames × 4 filler pairs) were arranged in blocks of three, each block containing one representative of each frame. During the course of the experiment, each subject heard each sentence pair only once. The order of conditions was assigned randomly, and the order of presentation of blocks was rotated so that 12 different orders were employed among subjects.

The twelve first-sentence versions (8 test and 4 filler) of each frame were recorded with normal intonation and at a rate of approximately 3.5 words per second. Master copies of the two second-sentence forms were recorded for each frame, and a tone was placed at the beginning of the verb phrase on the second channel of the tape, i.e., at the beginning of the verb in the affirmative form and at the beginning of the auxiliary in the negative form. These master copies were crossrecorded to produce the second sentences in each pair. A 400 ms silent interval occurred between the end of the first sentence and the beginning of the second. The tone, which was inaudible to the subjects, started timers that were stopped by their responses. Thirty-six M.I.T. students were paid for their participation in the 35 min experiment.

2. Results

The results are presented in Table XIV-3.

Table XIV-3. Experimental results.
[speed score means (1/RT)]

1st sentence main verb type of implication [positive + negative -]							
+ (.731)				- (.670)			

1st sentence form of assertion [affirmative + negative -]							
+ (.798)		- (.665)		+ (.677)		- (.663)	

2nd sentence form of assertion [affirmative + negative -]							
+ (.804)	- (.791)	+ (.750)	- (.579)	+ (.673)	- (.681)	+ (.727)	- (.599)

F-ratio df 1,22	Orthogonal Contrasts							
19.49	0	0	1	-1	0	0	0	0
0.04	0	0	0	0	1	-1	0	0
0.11	1	-1	0	0	0	0	0	0

Subjects' reaction times were transformed to speed scores (1/RT). An analysis of variance was performed on these scores, with one random between-subjects variable, order(12); one random within-subjects variable, frames(3); and three fixed within-subjects variables: type of implication for first sentence main verb (positive vs negative) × form of assertion for first sentence (affirmative vs negative) × form of assertion for second sentence (affirmative vs negative).

The results revealed that the FALSE-TRUE response difference characteristic of negative sentences was produced when the first sentence of the test pair contained a negatively asserted positive implicative (e.g., didn't manage) ($F_{(1,22)} = 19.49$, $p < .001$). But for affirmatively asserted negative implicatives (failed), there was no difference between FALSE and TRUE responses ($F < 1$). Thus the general pattern for negative sentences was replicated, but the findings of Just and Clark were not. Affirmatively asserted positive implicatives (managed) also failed to produce a difference between TRUE and FALSE responses ($F < 1$). Taken together, these results suggest that affirmatively asserted negative implicatives are not treated as negatively asserted positive implicatives, but rather are handled in much the same way as affirmatively asserted positive implicatives. The results seem to be inconsistent with the derivational view of negative implicative verbs.

Appendix

First Sentence

affirmatively asserted positive implicative
negatively asserted positive implicative
affirmatively asserted negative implicative
negatively asserted negative implicative

Second Sentence

affirmative assertion form
negative assertion form

FRAME 1

The acrobat managed to walk the tightrope.
The acrobat didn't manage to walk the tightrope.
The acrobat failed to walk the tightrope.
The acrobat didn't fail to walk the tightrope.

The acrobat walked the tightrope.
The acrobat didn't walk the tightrope.

FRAME 2

The robber succeeded in stealing the Crown jewels.
The robber didn't succeed in stealing the Crown jewels.
The robber refrained from stealing the Crown jewels.
The robber didn't refrain from stealing the Crown jewels.

The robber stole the Crown jewels.
The robber didn't steal the Crown jewels.

FRAME 3

The movie critic happened to see the award-winning picture.
The movie critic didn't happen to see the award-winning picture.
The movie critic avoided seeing the award-winning picture.
The movie critic didn't avoid seeing the award-winning picture.

The movie critic saw the award-winning picture.
The movie critic didn't see the award-winning picture.

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