Some syntactic determinants of sentential complexity, II: Verb structure[1]

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The effect of the lexical complexity of verbs on the processing of sentences was evaluated in two experiments. Verb complexity was indexed by the number of types of grammatical structure a verb permits (e.g., a verb may be transitive or intransitive and may permit various types of complement structures). Ss' performances in paraphrasing sentences and in solving anagrams containing complex verbs were significantly poorer than their performances with the same sentences and anagrams containing less complex verbs.

Any general solution to the problem of sentence recognition must provide an answer to the following question: How does the speaker determine the appropriate base structure analysis of an utterance in his language? In particular, given an utterance of a well-formed string of words, by what procedures does the speaker assign to that sequence an appropriate base structure tree? (For extended discussion of the notion "base structure tree" and related grammatical concepts, see Chomsky, 1965. For discussion of the perceptual strategies in the recovery of base structure trees, see Fodor & Garrett, 1967.)

Fodor and Garrett (1967) argue that a sentence recognition routine capable of inducing base structures given formative strings might consist of at least the following: (1) a component which projects candidate deep structure analyses of an input string by reference to the deep structure grammatical configurations which the lexical items in the string are capable of entering; and (2) a component which (when there is more than one such candidate analysis) chooses among candidate analyses by reference to explicit markers in the surface structure of the sentence. Roughly, the information exploited by the first of these processes is thought to derive from the lexical component of a generative grammar, while the information exploited by the second derives from its transformational component.

For example, the presence of the lexical item "whom" in (1) is the consequence of a transformation which derives (1) from a deep structure

(1) the man whom the dog bit died

configuration in which "the man" is object of a verb ("hit") of which "the dog" is subject. The presence of "whom" in the surface structure of (1) may thus be thought of as a 'spelling' of that deep structure configuration. This spelling is, however, ambiguous. That is, the presence of the surface structure configuration (2) does not uniquely determine the base structure

(2) NP_1 whom NP_2

configuration (3). Rather, the inference from surface structures like

(3) NP_2 = subject Verb NP_1 = object

(2) to deep structures like (3) requires at least information about the grammatical character of the verbs to which the NPs are related. Notice that sentences like (4) exhibit the surface configuration (2), but not the

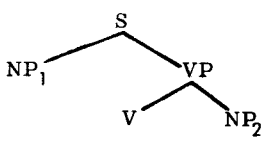
(4) the man whom the girl knows John likes got ill

base structure (3).

Fodor and Garrett showed that the introduction of relative pronouns in the NP sequence of doubly embedded center branching sentences facilitates their comprehension. It was argued that Ss' ability to exploit the presence of the pronoun must depend on their application of a lexical analysis of the verb. In particular, Ss must take account of the transitivity of the verbs in the sentence since the inference from structures like (2) to structures like (3) is warranted only when the relation between NPs is mediated by transitive verbs.

Implicit in this analysis is the suggestion that the deep structure properties of the verb play a major role in S's determination of the base structure of an input sequence. It is this suggestion that leads to the present investigation.

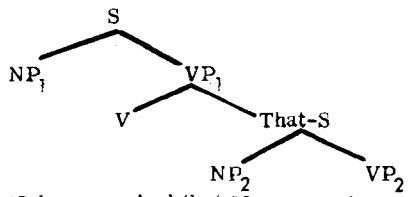
Verbs may be classified in terms of the types of deep structure configurations they can dominate. For example, to say of the verb V that it is transitive is just to say that in the deep structure it accepts the configuration (5). To say that it is a *pure* transitive is to say that it accepts *only* deep structure configurations like (5).



(John discussed the book)

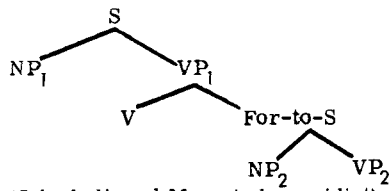
Analogously, verbs may permit various sorts of complements (cf. Rosenbaum, 1967). That is to say, they

may enter into various configurations of matrix and constituent sentences in the deep structure of a sentence. Thus, a verb like "remark" permits deep structures such as (6), but not configurations like (5).



(John remarked that Mary came)

On the other hand, "believe" permits either configurations like (5) (e.g., John believed Mary), or like (6) (John believed that Mary came), or like (7).



(John believed Mary to be an idiot)

The above proposal for a sentence recognition procedure, if correct, would suggest that these sorts of lexical properties of verbs are exploited in the assignment of base structure. Thus, given a sentence containing the main verb "discuss," the S can instantly determine the gross characteristics of its deep tree; i.e., it must have the general form of (5) since "discuss" is a pure transitive. On the other hand, given a sentence with the main verb "believe," S may hypothesize either base configurations like (5), or like (6), or like (7) since the lexical structure of "believe" is compatible with all three. Presumably, given an unambiguous sentence in which "believe" is the main verb, S must decide between these various possible deep structures by reference to such explicit surface structure features as the occurrence of "that" in (6), of "to" in (7), of tense in the subordinate clause of (8) (see Fodor and Garrett, 1967), etc.

(8) John felt the ground trembled

There is thus a difference between the lexical analysis of "discuss" and similar verbs and the lexical analysis of "believe" and similar verbs; verbs of the latter kind are compatible with a wider range of hypotheses about the deep structure of the sentences in which they appear than are verbs of the former kind. This, in turn, suggests that sentences containing verbs like "believe" ought, ceteris paribus to be more difficult to understand than sentences containing verbs like "discuss." This is a consequence of the suggestion that the lexical character of the verb is an important determinant of the number of hypotheses about the base structure of a sentence which must be entertained.

We have hypothesized that the heuristics employed in the recognition of sentences exploit information concerning the lexical structure of the sentence's verbs: In general, the greater the variety of deep structure configurations the lexicon associates with the main verb of a sentence, the more complicated the sentence should be. The ease with which a sentence is understood should, therefore, be in part a function of this variable.

In a preliminary study we found some support for this view. For doubly self-embedded sentences (of the sort used by Fodor and Garrett), the presence of complement verbs was associated with greater difficulty in understanding sentences.

For this pilot study we constructed 12 pairs of stimulus sentences. The members of the pairs differed by the use of a complement verb in one version and the use of a transitive verb in the other.[3] The stimulus sentences were typed onto 3 x 5 file cards. The Ss were shown a sentence for a 3-sec period and then requested to paraphrase the sentence as accurately as they could and with as little delay as they could manage. The Ss were given five successive attempts at each of the stimulus sentences.

An accuracy of paraphrase score was determined from the number of subject-verb-predicate triples that were correctly reported. For example, if S was shown the sentence:

> The box the man the child knew carried was empty

and produced the paraphrase:

> The child carried the box the man knew was empty

his score would be 1 for his correct recovery of the triple "the box was empty." The S's paraphrase in this case would fail to correctly represent the triples "the man carried the box" and "the child knew the man."

Half of the stimulus items that S was presented with had a complement verb and half did not. Twenty Ss were run in this pilot study. Significantly more Ss showed poorer performance scores on the complement verb sentences than on the simple transitive verb sentences; 14 Ss showed poorer performance on complement verb sentences, five on transitive verb sentences, and one S showed no difference ($p < .005$, Wilcoxon test). An analysis by sentence was also made. Subject means for the members of each pair of stimulus sentences were compared (i.e., the mean paraphrase score for the 10 Ss who saw the complement verb versions of the sentences was compared with the mean of the 10 Ss who saw the pure transitive versions). In 11 of the 12 comparisons, Ss produced more accurate paraphrases for the sentences which did not contain a complement verb ($p < .005$, Wilcoxon test).

The results of the pilot study support the hypothesis that verb complexity (measured in terms of number of potential base structures) affects Ss' performance on

sentence comprehension. There were some problems with the stimulus materials in the pilot experiment, however. The most serious difficulty was that of ambiguity. It is an unfortunate concomitant of the introduction of complement verbs that one also creates the possibility of syntactic ambiguity in several of the sentences used.[4] Though the ambiguity must be considered as a possible source of difficulty for Ss in the pilot experiment, it cannot fully account for the differences. Eleven of the 12 sentence pairs showed greater difficulty associated with the complement verb, but only six of the sentences were potentially ambiguous. Moreover, if the ambiguity were primarily responsible for the performance differences in the experiment, one would expect to have a weaker effect among the unambiguous sentences. In fact, the one reversal (poorer performance on the *non*complement version) was one of the ambiguous sentences, and overall the magnitude of the complement verb effect was slightly *greater* for the unambiguous sentences.

Experiment 1, reported below, is an auditory version of the pilot experiment. In this experiment, greater control over the possible ambiguity was exercised by tense selections and by verb positioning. The auditory presentation, moreover, is more akin to natural decoding situations. The presence of intonation, stress, etc., makes the stimulus sentences more acceptable to Ss.

EXPERIMENT 1

Stimulus materials

Twelve pairs of sentences with two levels of self-embedding were constructed. The members of each pair differed only in that one contained a verb which permitted complement structures where the other contained a transitive verb. The sentences are listed below with the complement verb underlined in each case.

(1) The box the man the child (a) knew (b) met carried was empty.

(2) The letter the secretary the manager employed
(a) mailed
(b) expected was late.

(3) The actors the writer the agent sent (a) saw (b) used were talented.

(4) The deer the man the boy followed (a) fed (b) heard were timid.

(5) The plan the lawyer the client interviewed
(a) proposed
(b) devised was impractical.

(6) The material the tailor the designer used
(a) cut
(b) required was green.

(7) The tiger the natives the hunter (a) preferred (b) paid hated was fierce.

(8) The planes the sailors the enemy attacked
(a) evaded
(b) feared were bombers.

(9) The tactics the general the soldiers admired
(a) suggested
(b) adopted were stupid.

(10) The events the papers the man bought
(a) discussed
(b) reported were unsettling.

(11) The insult the waiter the lady summoned
(a) intended
(b) provoked was obvious.

(12) The results the scientist the committee (a) ignored appointed (b) predicted were surprising.

Two groups, A and B, were derived from the list such that in each group half the sentences contain complement verbs and half do not. Under these conditions, the performance levels for each S on the two types of sentences can be compared, as can the performance across Ss on the two versions of each sentence.

Procedure

The sentences were tape recorded. They were read with full intonation. That is, emphatic stress and pause were used to indicate the intended sentence structure. It was intended thereby to preclude the irrelevant interpretation of fully or partially ambiguous sentences insofar as possible (The 'normal' intonation pattern is quite different for the two versions of the ambiguous sentences, whether the ambiguity is full or partial.)

Thirty M.I.T. undergraduates were used as Ss. All Ss were volunteers who were paid for their participation in the experiment. An S was required to restate the sentence in his own words as soon as he was able to do so. They were told that we would measure both their accuracy and the time it took for them to do the task. The Ss were *not* permitted exact repetition, since it was found in earlier work that a rote repetition of sentences of this type and length was quite possible for Ss even when they did not understand the sentence. There were five successive presentations of each of the 12 sentences that an S was given. Responses were tape recorded.

Results

The accuracy of the paraphrase responses was scored as described for the pilot study. Since each sentence had three propositions which could be recovered, the maximum score that could be achieved by an S for the five presentations of a sentence was 15. Table 1 reports the accuracy of paraphrase scores for the 12 sentence pairs. (Each sentence is referred to by a key word.)

Performance overall was better in Group B than in Group A. In order to permit a sentence-by-sentence comparison, the scores of Ss in Group B were trans-

Table 1.
Mean Number of Subject-verb-object Triples Correctly Recovered per Sentence for Auditory Presentations

Sentence number	Complement version	Noncomplement version	Sentence number	Complement version	Noncomplement version
(1) box	10.9	11.3	(7) tiger	9.9	11.3
(2) letter	10.4	11.1	(8) planes	7.6	8.4
(3) actor	6.5	6.7	(9) tactics	13.1	12.8
(4) deer	11.3	10.9	(10) events	11.8	13.8
(5) plan	9.3	10.9	(11) insult	11.3	12.1
(6) material	9.4	10.1	(12) results	11.9	12.1

formed to the same mean as those in Group A. As Table 1 shows, for the sentence-by-sentence comparison, the versions containing a complement verb have a lower score on the paraphrase measure than do their counterparts without complement verbs in 10 out of 12 instances ($p < .005$, Wilcoxon test). There are five confirming and one disconfirming comparison for each group.

Half of the stimulus sentences received by an S contained complement verbs and half did not. Hence, it was possible to examine the performance of individual Ss on the two sentence types. Of the 29 Ss who showed a difference between their scores for complement and noncomplement sentence types, 20 showed larger paraphrase scores for the noncomplement versions ($p < .005$, Wilcoxon test).

It will be recalled that Ss were instructed to perform the task as quickly as they were able consonant with accuracy. Accordingly, we determined the response delays (the interval from end of stimulus to onset of S's response) from the response tapes. Our expectation was that accuracy of paraphrase would be positively correlated with length of response delay. We did find a tendency for complement versions of sentences to show longer response delays than their noncomplement counterparts. The effect is very weak, however, and is not significant.

Discussion

Presentations of the stimulus material both visually (in the pilot experiment) and auditorily (in Experiment 1) showed a performance decrement for those sentences containing the more complex verbs. This was true both for sentence-by-sentence contrasts across Ss and for the performance of individual Ss on the two types of sentences. This result strongly suggests the hypothesized interaction between the lexical structure of the verbs in a sentence and the strategies speakers use to recover its deep structure.

A word needs to be said concerning the failure of the response delay measure to show the expected asymmetry. Though response delay and paraphrase measures were highly correlated in our earlier work with similar experimental tasks, this was not true in the current experiment. Though there was a trend for slightly greater response delays to be associated with complement verbs, it was not significant, and the effect was very weak. (Moreover, when response delay measures were determined for the pilot experiment, a weak shift in the reverse direction was found.) The best that can be said of the response delay measure in the current experiment is that its effectiveness may have been reduced by the greater tendency of Ss here to hesitate and flounder during their paraphrasing. Though we have made no quantitative assessment of the change, it is our impression that Ss were much less fluent than in the former experiments. We also found that, overall, the response delays were lower in this experiment than in Fodor and Garrett (1967). Both these facts become reasonable if one supposes that Ss often assumed a stimulus sentence to be easier than they found it to be. That is, Ss began to speak prematurely (thus decreasing response delays), and then discovered the difficulties afterwards (thus the increased nonfluency of Ss for this experiment).

Setting aside the nonsignificant response delay results, the paraphrase results appear to demonstrate clearly that the character of the verb structure is an important consideration in determining the ease of understanding sentences in this experiment. As we noted in our discussion of the pilot results, the potential ambiguity of some of the complement verb sentences provides the most plausible alternative to this conclusion. As before, however, we can reject this possible explanation of the difficulty of the complement verb sentences on the grounds that (1) the unambiguous cases of complement verb sentences all show the predicted asymmetry (2) the only two reversals of the expected effect occur among the ambiguous versions and (3) the magnitude of the performance decrement is approximately the same for both the ambiguous cases and the unambiguous cases (in fact, the mean effect for the unambiguous versions is slightly greater).

A further analysis of the paraphrase responses provides additional support for the view that it is the complex lexical structure of the complement verbs that produces difficulty and not some other property of the stimulus sentences. The Ss frequently reported only part of the stimulus sentences in their paraphrases—that is, portions of the input were omitted in their response. If one compares the incidence of *verb* deletions for complement and noncomplement verbs in the same environments, it is found that Ss were

much more likely to omit a complement verb than a noncomplement verb; complement verbs were dropped 266 times while noncomplements were dropped 167 times. By sentence, the difference is significant; in eight of the sentences more complement verbs were dropped, in three, more noncomplements were dropped, and in one, no difference ($p < .05$, Wilcoxon, two tails).

Further evidence which indicates the central importance of the verb in the analysis of self-embedded sentences comes from a study by Bever (1967). Bever found that for doubly self-embedded sentences paraphrase scores are *higher* for sentences with multisyllabic verbs than for their counterparts containing monosyllabic verbs. A similar variation in the length of nouns in such sentences, however, did not affect the accuracy of paraphrase. If it is assumed that the increase in the length of a word provides an increase in the time available for computation of the sentence structure, this finding indicates more computational activity while the verbs are being analyzed, since increase in computational time helps only when at the locus of the verbs.

EXPERIMENT 2

While the results of the experiments with self-embedded sentences appear to offer persuasive evidence for the role of verb structure in determining sentential complexity (and hence for the role of the main verb in determining the candidate analyses S considers as possible deep structures for a sentence), it seemed desirable to test this view of structure assignment with a different experimental paradigm. We wished to use stimulus materials which would avoid entirely the problems with ambiguity raised in the case of the self-embedded complement structures. Further, we desired that the stimulus materials be more 'natural' examples of sentences than those used in Experiment 1.

An experiment was therefore performed in which Ss' task was the construction of a sentence from a scrambled set of words. The use of an anagram task to evaluate the complexity of sentences is not novel. Marshall (1964) found this sort of task yielded the same complexity orderings for optional singulary transformations as found by Miller and McKean (1964) and others.

Stimulus materials

The stimulus sentences are given in the list below. Each sentence occurs in two versions differing only in that one version has a main verb which takes both complement structures and direct objects while the other version has a transitive.

(1) The man whom the child (a) knew (b) met carried a box.

(2) The girl in the movie really did (a) kick (b) like the salesman.

(3) The letter which the secretary (a) expected (b) mailed was late.

(4) Although he was very sick the dictator (a) disobeyed (b) resented the doctor's advice.

(5) The actor whom the agent (a) saw (b) sent was talented.

(6) The tired movie star (a) indulged (b) granted his public's requests for autographs.

(7) The boy whom the man (a) found (b) followed was very ill.

(8) He had good reasons not to (a) greet (b) acknowledge his old friends.

(9) The ambassador (a) ordered (b) borrowed ten cases of brandy from his nephew.

(10) The lawyer whom the client (a) hired (b) believed was honest.

(11) Congress quickly passed the controversial (a) requested. bill which the president (b) drafted.

(12) The tailors whom the designer (a) needed (b) required belonged to a union.

(13) The judge (a) decided (b) biased the case in favor of the corrupt politician.

(14) The natives whom the hunter (a) paid (b) prefers are hard workers.

(15) The janitor (a) reported (b) hit the tenant who complained about the high rent.

(16) The commander (a) relayed (b) announced the news of the armistice to his troops.

(17) The planes which the enemy (a) feared (b) evaded were bombers.

(18) The tactics which the general (a) adopted (b) suggested were stupid.

(19) The chief of police (a) doubted (b) ignored the story of the watchman's brother.

(20) The manager (a) blamed (b) recommended John when the company ran short of help.

(21) The committee (a) considered (b) deleted all the arguments for abolishing private property.

(22) The events which the papers (a) discussed (b) reported are unsettling.

(23) The book was badly written but it (a) revealed (b) contained

some important facts.

(24) The insult which the waiter (a) provoked (b) intended was obvious.

(25) The condemned prisoner (a) demanded (b) obtained a pardon from the governor's office.

(26) The accomplice had (a) hidden (b) warned the murderer the moment the police arrived.

(27) The government (a) permitted (b) ended the shipment of medical supplies to the guerillas.

(28) The results which the scientist (a) ignored (b) predicted are surprising.

(29) The old theory obviously (a) required (b) contained several false assumptions about cosmology.

(30) The villagers (a) killed (b) remembered the evil witch doctor from the next district.

It will be noted that, as in Experiment 1, none of the sentences actually contain a complement construction; i.e., whether or not the main verb is grammatically *capable* of accepting a complement, its role in the stimulus sentence is that of dominating a direct object.

In addition to the stimulus sentences listed, Ss also received fifteen "padding" sentences. The padding sentences, which were distributed among the stimulus sentences, all contained a complement verb which in fact dominated a complement structure. The list of stimulus sentences and padding sentences received by a S, therefore, was balanced in the following way: 15 sentences with transitive verbs and direct objects; 15 sentences with complement verbs and direct objects; 15 sentences with complement verbs and complement constructions. As in Experiment 1, therefore, both an analysis by sentence (the two versions of each test sentence compared) and an analysis by subject (the comparison of S's performance on complement verb sentences with his performance on noncomplement verb sentences) is possible.

Procedure

The stimuli presented to each S consisted of individual words typed in capitals on small pieces of file card. The material was presented by placing the fragments haphazardly before him. The S was requested to arrange the fragments serially so that they formed a grammatical and meaningful sentence. He was also instructed to perform the task as quickly as possible consonant with accuracy. In order to motivate his best possible performance, S was given a schedule of small cash incentives for rapid performance. No S was allowed more than 60 sec to complete a sentence. Thirty Ss were run individually and all were paid a minimum fee ($1.40) regardless of the level of their performance.

The S was timed with a stopwatch starting from the presentation of the stimulus materials. The watch was stopped when S announced his completion of the presented sentence.

Scoring. The Ss' responses fall into three categories: (1) instances in which a sentence was correctly constructed within the alloted 60 sec; (2) instances in which S announced his completion within 60 sec but had in fact failed to produce an acceptable sentence; (3) instances in which S failed to produce an acceptable sentence within 60 sec. In the cases where S failed to produce an acceptable sentence, a record was kept of the sequence he produced. The data were thus analyzable in terms of number of correct completions, number of erroneously reported completions, and response times for acceptable completions.

Results

If we consider only the response times for correct solutions to the sentence construction task, we find no significant difference between complement and noncomplement versions of the sentences. There are 30 test sentences; median scores for each version of a test sentence were computed using only the values from S who constructed the sentence correctly. Of the 30 sentences, 16 had larger medians for the complement version while 14 had larger medians for the noncomplement versions.

However, if we consider those instances in which Ss either failed to complete the task or produced an incorrect sentence, we find a marked difference between the complement and noncomplement versions of the sentences. Table 2 gives the sentence-by-sentence comparisons for false reports (S announces his solution to be a sentence when it is not) and failures to complete.

Of the 30 test sentences, 13 showed more frequent failures to complete in their complement versions, four showed more in their noncomplement versions, and 13 showed no difference ($p < .05$, Wilcoxon test). The analysis by sentence for false reports shows the same pattern; 14 sentences show more such errors in their complement versions than in their noncomplement versions, eight show more for the noncomplement version, and eight show no difference ($p < .05$, Wilcoxon test). If we consider the sentence-by-sentence results for both measures combined, we find that on 17 of the sentences there were more errors for complement than for noncomplement versions and five sentences for which the reverse was true ($p < .005$, Wilcoxon test).

The greater difficulty of the complement versions of the sentences is also borne out when the performance of individual Ss is considered. Of 30 Ss, 18 made more errors on the complement sentences they received than on the noncomplement sentences, six Ss showed the reverse effect, and six performed equally well on both types of sentence.

Discussion

The Ss' performance in the solution of the anagram task seems strongly dependent on the nature of their

Table 2. Numbers of False Reports and Failures to Complete for Each Stimulus Sentence in Both Complement and Noncomplement Versions

Sentence number	Complement versions: Failure to complete	Complement versions: False report	Complement versions: Combined score	Noncomplement versions: Failure to complete	Noncomplement versions: False report	Noncomplement versions: Combined score
(1)	3	5	8	2	5	7
(2)	2	2	4	0	2	2
(3)	0	1	1	0	1	1
(4)	3	0	3	0	2	2
(5)	0	7	7	3	5	8
(6)	3	5	8	4	2	6
(7)	1	2	3	0	3	3
(8)	3	3	6	2	0	2
(9)	0	2	2	0	1	1
(10)	2	3	5	2	2	4
(11)	2	1	3	0	2	2
(12)	7	5	12	7	3	10
(13)	3	2	5	5	2	7
(14)	4	5	9	0	1	1
(15)	2	0	2	1	1	2
(16)	0	0	0	0	1	1
(17)	1	5	6	1	1	2
(18)	2	1	3	0	0	0
(19)	2	3	5	2	3	5
(20)	5	2	7	0	1	1
(21)	1	1	2	1	2	3
(22)	1	0	1	0	1	1
(23)	1	2	3	1	0	1
(24)	3	1	4	1	3	4
(25)	0	4	4	0	0	0
(26)	2	0	2	2	0	2
(27)	0	2	2	2	1	3
(28)	0	1	1	0	0	0
(29)	2	1	3	1	1	2
(30)	0	1	1	0	1	1

assumption concerning the relationship of the verb to the rest of the sentence. Particularly convincing on this point are those instances in which Ss misperceived the results of their "word shuffling" as sentences when in fact they were not. As we noted above, this misperception happened much more frequently for sentences involving complement verbs than for those not involving complement verbs. Moreover, an analysis of the kinds of errors that were made when Ss incorrectly reported a completion reveals a marked difference between the complement verb cases and the noncomplement verb cases. For the cases in which S produced an incorrect solution (which he labelled correct) for a noncomplement version of a sentence, the error was almost invariably one of getting an adjective or an article out of order (e.g., "the man old ran away" for "the old man ran away," or "the commander relayed the the news of armistice to his troops," etc.). When Ss incorrectly reported completion for complement verb versions of sentences, however, it was frequently the case that there was a serious structural error (e.g., "the waiter intended which was obvious the insult" for "the insult which the waiter intended was obvious," or "a doctors treatment for minor cuts consider iodine to be poor now" for "doctors now consider iodine to be a poor treatment for minor cuts," etc.).

These results appear to be compatible with the following analysis. When S isolates the main verb he makes a guess about the structure of the sentence in which it appears. The options available to him are governed by the lexical character of the verb (i.e., transitive, complement, or mixed). When he guesses correctly, no interference measurable by this paradigm is produced by the existence of irrelevant options; he performs as well with mixed verbs as with pure transitives. When, however, his guess is incorrect, various consequences of interference are evident; among these are failure to complete the task and misperception of the structure of the stimulus.

While it is impossible to prove that the anagram task illuminates specifically perceptual processes in sentence analysis, it does appear to illustrate the centrality of the lexical character of the main verb in the integration of linguistic objects. The anagram results thus appear to support the conclusions derived from Experiment 1.

GENERAL DISCUSSION

The results reported here provide support for the view advanced in Fodor and Garrett (1967). It appears that the exploitation of the lexical analysis of the main verb of a sentence is a central heuristic in the strategy Ss use to recover its deep structure. This view in turn has a rather direct implication for further research

both in linguistics and in psychology. We have presupposed as input to the sentence recognition process a representation of the sentence which marks at least a crude segmentation, including the identification of the main verb. That is, for a syntax recognition device to employ the lexical structure of the main verb as a clue to the possible geometry of the deep structure tree underlying an input, it must at least have available some hypotheses about what the main verb of the input string is and about what substretches of the string constitute segments of the sentence which the main verb may dominate in deep structure. Hence, the postulation of some pre-analysis of the sentence which marks putative relations between verb and noun phrases is a plausible hypothesis on the current view.

There are three sources of evidence pointing to the existence of this sort of pre-analysis. First, there is the difficulty of center embedded constructions, which probably is contributed in part by the difficulty of determining which verb phrases are related to which noun phrases. That is, in such sentences there is no direct correspondence between surface structure clause adjacencies and deep structure relations (cf. Fodor & Garrett, 1967).

Second, there appears to be linguistic evidence for the existence, at least in English, of certain grammatical asymmetries between the part of the sentence on the left hand side of the main verb and the part to its right. As Mr. R. Kirk has pointed out to us, in English the deletability of certain lexical items appears to be constrained by their position relative to the main verb of the sentence. For example, in the sentence "it is obvious (that) John was bored," the presence of the lexical item "that" is optional. However, in the sentence "that John was bored was obvious," the lexical item "that" may *not* be deleted; "*John was bored was obvious." It is not implausible to assume that the point of such restrictions is to help the speaker distinguish between the case when the first verb in a sentence is its main verb and the case when it is merely the main verb of an embedded clause. This is by no means the only example of its kind (see Fodor, Bever, & Garrett, in preparation).

Third, there exists a certain amount of experimental evidence for the view that it is not primarily the immediate constituent but rather the clause that provides the perceptual unit in speech (see Bever, Fodor, & Garrett, 1966). If this view is correct, it argues for the existence of a level of processing which provides just the sort of pre-analysis of the input string presupposed by the view of deep structure recovery we have been presenting.

The following is suggested as an outline for a solution to the problem of how the deep structure of sentences is recovered. It is assumed that each verb has a characteristic lexical structure which is represented in the recognition device by a set of conditions upon deep structure trees into which the verb can enter. In particular, it is assumed that the lexical analysis of each verb in the language is part of the information a S has about the structure of his language. Applying this information to an input involves analyzing the input as a substitution instance of one or another of the base structure arrays its verb is capable of dominating. The pre-analysis routine ought thus to provide as much information as possible as to which structures in the sentence are NPs and VPs and which of the NPs each VP is related to. Given such information, a systematic exploitation of the lexical analyses associated with verbs and of transformationally introduced surface structure grammatical markers (such as inflection, relative pronouns, order, etc.) may prove to be sufficient to uniquely specify an underlying geometry for each input sentence.

This conception of the sentence processing routine makes a strong claim concerning the role of the verb in sentence decoding. The experiments reported in this paper provide some evidence for that claim. It should be remarked however, that the considerations that hold for verbs may well have analogues for other parts of speech. Thus, for example, it is quite conceivable that the lexical structure of nouns and/or adjectives is exploited by the sentence recognition device, in which case the lexical complexity of such formatives ought to contribute to the perceptual complexity of sentences. Experimental determination of the perceptual consequences of lexical complexity in the case of formatives other than verbs would therefore be most important for the further evaluation of models of the sort we have proposed.

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Notes

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2. Dr. Bever is now at Rockefeller University.

3. We have designated the classes of verbs contrasted in these experiments as complement and transitive verbs. This classification refers to object complementation. There are other types of complementation which we have not discussed here (see Rosenbaum, 1967). Though the linguistic analysis is not clear in the case of every verb we have used, the verbs we have referred to as complements are compatible with a wider range of structures than those referred to as transitive even when other complement types are taken into account.

4. An example is Sentence (9) (p. 456) for which the intended reading is "the general suggested stupid tactics" but which permits the reading "the general suggested that the tactics were stupid." (The reader may have to read the sentence aloud to convince himself of the possibility of this interpretation. The following punctuation suggests the ambiguity: "The tactics, the general the soldiers admired suggested, were stupid.")

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