Reprinted from JOURNAL OF VERBAL LEARNING AND VERBAL BEHAVIOR, Volume 2, Number 4, November 1963

JOURNAL OF VERBAL LEARNING AND VERBAL BEHAVIOR 2, 346-351 (1963)

Some Effects of Grammatical Transformations on the Recall of English Sentences[1]

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It is an all too common observation that we can understand the general significance of a verbal message even though we may be unable to repeat the exact words in which it was originally expressed. To give a precise account of all that goes on under these circumstances would, of course, be difficult if not impossible; yet it has been possible to isolate some aspects of the process and to study them by experiments on the memorization of connected discourse. The present paper represents an attempt to extend this general line of investigation by exploiting certain concepts that have proved useful in descriptive linguistics.

The fact that a person can often rephrase "in his own words" the general sense of a message that he has not yet memorized in precise detail would seem to indicate that semantic components of a meaningful message are generally easier to recall than are its specific grammatical details. In the present experiment, therefore, we have attempted to explore this possible difference in a systematic manner. In general terms, the strategy adopted was the following: a set of eight short sentences was presented to the *S*, who was instructed that he would be tested for recall. The sentences differed systematically in their grammatical forms; they might be either active or passive, affirmative or negative, declarative or interrogative. The *S*'s responses were then scored both for semantic accuracy (did he recall one of the eight sentences, regardless of grammatical form?) and for syntactic accuracy (given that a sentence was recalled, was its grammatical form correct?). The results of a preliminary study using this general approach have already been reported by Miller (1962).

The syntactic description used here is essentially Chomsky's (1957). According to Chomsky's grammar, most sentences are derived from more fundamental ones by certain special rules, called transformations. The fundamental, or kernel (*K*), sentences are, in the vocabulary of traditional grammar, simple, active, affirmative, declarative sentences, such as *The boy has hit the ball, The girl has worn the jewel,* etc. Only three grammatical transformations are considered in this experiment: the negative (*N*), the passive (*P*), and the interrogative (*Q*). When the *N* transformation is applied to *The boy has hit the ball* it produces a new sentence, *The boy hasn't hit the ball.* When *P* is applied to the same *K* sentence, it produces *The ball has been hit by the boy.* The *Q* transformation applied to the same *K* sentence produces *Has the ball been hit by the boy?* These transformations may also be applied in combination to produce, for example, a passive-negative-question

[1] This research was supported by funds from the Public Health Service research grant No. M-05120-02 from the National Institutes of Health, by the National Science Foundation grant No. NSF-G-16486, and by the Carnegie Corporation of New York, to Harvard University, Center for Cognitive Studies.

I want to express my gratitude to Professor G. A. Miller for his advice on the form and content of this paper. Also I want to thank Dr. H. B. Savin for his criticism of earlier drafts and for the encouragement he gave me.

(*PNQ*), *Hasn't the ball been hit by the boy?*

Application of these transformations in all possible combinations will generate seven transformed sentences for each *K*. The relations between these eight sentences can be simply represented by a cube, as in Fig. 1,

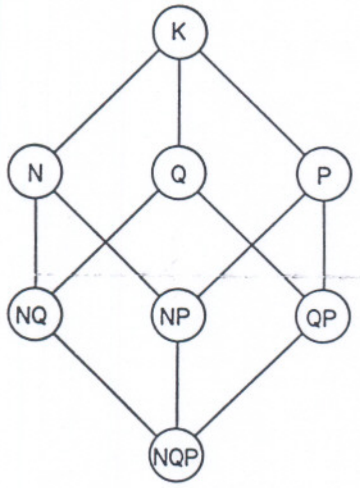

FIG. 1. Syntactic relations of the eight sentences. Each vertex corresponds to a type of sentence, and adjacent vertices correspond to pairs of sentences that differ only by one transformation.

where each vertex corresponds to a type of sentence, and adjacent vertices correspond to pairs of sentences that differ by only a singular transformation.

METHOD

Materials

The following eight kernel sentences were used: *The man has bought the house; The boy has taken the photograph; The biologist has made the discovery; The girl has worn the jewel; The student has written the essay; The car has hit the tree; The airplane has carried the passenger;* and *The secretary has typed the paper.* The eight kernel sentences, together with their seven transformations, give 64 sentences, which were divided into eight groups of eight sentences in such a way that in each group no sentence and no transformation were represented more than once. Each of the eight groups of sentences was the experimental material for one group of *Ss*.

Procedure

Each set of eight sentences was presented for five successive trials, each time in a different order. Ten *Ss* at a time (chosen randomly) listened to the sentences, which were recorded on magnetic tape with a separation of 2 sec. between the end of one sentence and the beginning of the next.

After each presentation, *Ss* attempted to recall the sentences; they wrote their responses in a recall booklet that had five pages, one for each of the five trials. On each page were listed eight prompting words, one for each sentence; four of these prompting words were subjects and four were predicates. For example, a page in the booklet might contain the words *man, boy, biologist, girl, tree, essay, paper, airplane,* listed vertically on the page. The use of prompting words to improve the recall of the underlying kernel sentences is the principal methodological difference between the present experiment and the preliminary study reported by Miller (1962).

The instructions asked the *Ss* to complete their recall as quickly as possible, although no definite time limit was specified.

There were 80 *Ss*, all native speakers of English currently enrolled in an American university.

RESULTS

Figure 2 shows the acquisition curves for each of the various transformations, where per cent recalled correctly is plotted as a function of the trial number. The most striking fact in Fig. 2 is the greater facility with which *Ss* learned the kernel sentences. At each trial the difference between *K* and all the other types of sentences is significant at least at $p < .005$ for the first and last trials and at $p < .001$ for the other three trials. In this experiment the number of words in a sentence was not a good predictor of the ease of learning; although the *P* sentences contained more words, they were somewhat better learned than the *Q* sentences.

Figure 3 presents the percentages of the various kinds of errors that occurred on successive trials. A sentence was scored by means of the following rules:

(a) A sentence is scored as *correct* if it is a verbatim reproduction of the stimulus sentence or if it differs from the stimulus sentence only by (i) the replacement of a word

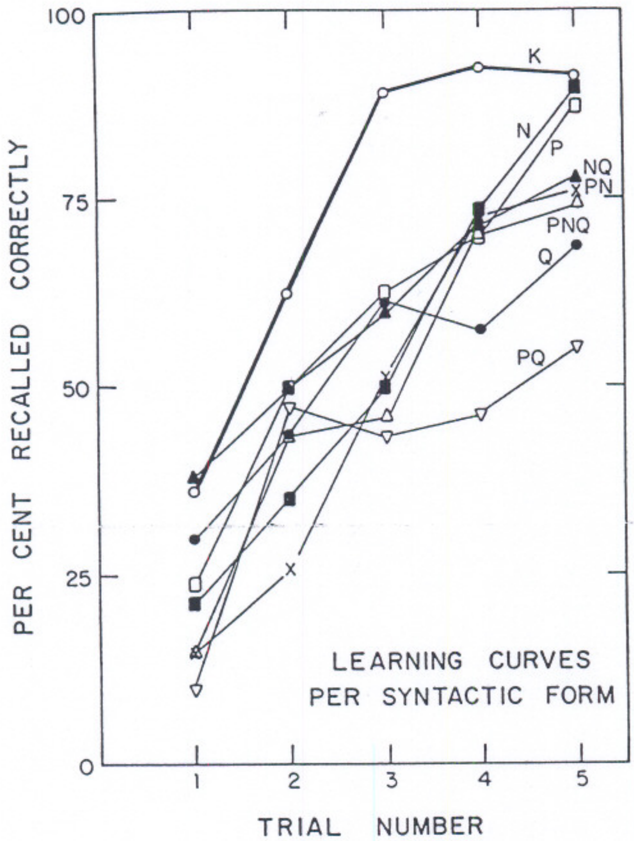

FIG. 2. Acquisition curves for each of the transformed sentences. The kernel is learned with greater facility than any of the other sentences.

TABLE 1
ERRORS IN RECALL

	Responses								
Stimuli	K	N	Q	P	NQ	NP	QP	NPQ	Totals
K	300	14	12	14	8	4	1	3	356
N	36	234	20	3	29	11	6	2	341
Q	31	16	210	1	72	2	8	12	352
P	43	3	8	243	15	10	30	13	365
NQ	29	15	31	3	221	3	7	23	332
NP	6	49	9	18	16	191	16	31	336
QP	13	5	32	27	29	15	145	60	326
NPQ	2	2	14	16	44	5	38	182	303
Totals	460	338	336	325	434	241	251	326	2711
Per cent of total number of errors	16.2	10.5	12.8	8.3	21.6	5.1	10.8	14.6	

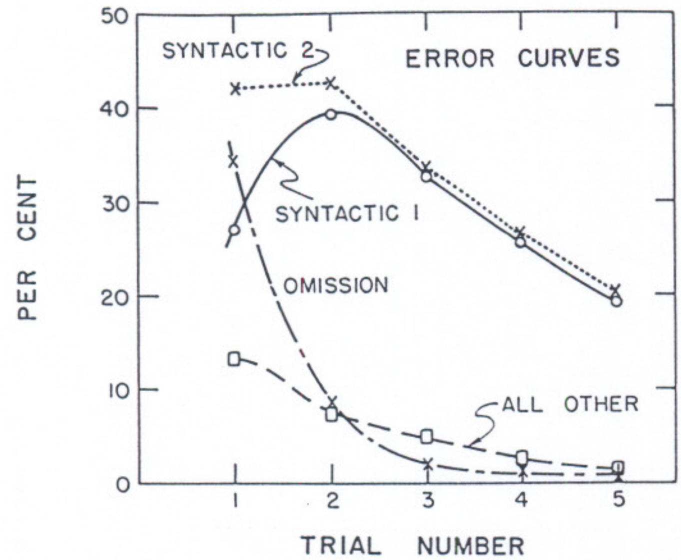

FIG. 3. Errors in free recall of sentences. The curve labeled *Syntactic 1* gives the proportion of all sentences that are syntactic errors. *Syntactic 2* shows the same proportion of actual responses that are syntactic errors. *Omitted* gives the proportion of all sentences that were completely omitted. *All others* gives the proportion of miscellaneous errors (e.g., inventions).

by a synonym; (ii) a change from the definite to the indefinite article; and/or (iii) a change in tense.

(b) A sentence is scored as a *syntactic error* if and only if it can be derived from a correct sentence [as defined in (a) above] by applying one or more of the singular transformations *P, Q,* or *N* or their inverses. If a recalled sentence is correct except for a syntactic error, then by definition its *sentence-content* is the same as the one in the original sentence.

(c) A sentence is said to be omitted when no recognizable part of it occurs in recall.

(d) All other errors are errors that do not fit any of the above categories.

Among the various types of other errors were pure inventions, partial inventions, conjugation of two sentences, etc. In Fig. 3 it can be seen that omissions drop steeply between Trials 1 and 2 and remain at a low level thereafter. Syntactic errors, however, increase to a maximum around Trial 2 and then decrease; this inflection is due, of course, to the many omissions on the first trial, as can be seen from the curve labeled SYN 2, since *Ss* could not make syntactic errors on the sentences they did not remember at all.

A matrix showing the total number of syntactic confusions of each type on all five trials is given in Table 1; the rows indicate the syntactic form of the sentence that was presented, the columns indicate the syntactic form of the sentence that was recalled, and the cell entries give the raw frequencies of occurrences of each stimulus-response combination. Entries on the main diagonal, of course, indicate the number of sentences of each type that were correctly recalled. The bottom row of the matrix gives the proportion of the total number of errors of each syntactic category.

The probability of coding correctly the sentence-content of the sentences is .85. The probabilities of recalling correctly each of the transformations are respectively $p_N = .81$; $p_P = .83$; $p_Q = .86$.

Discussion

These results suggest a partial answer to the question of how *S* can remember the general sense of a sentence even when he cannot repeat it verbatim. Very roughly, the suggested answer is that *S*s do not recall the sentence verbatim, but rather that they analyze it syntactically and encode it as a kernel sentence plus appropriate transformation. For example, if the sentence is *The ball has been hit by the boy,* then *S* presumably codes it as an underlying kernel plus some "mental tag" that indicates that the passive transformation must be applied for recall. Exactly how the kernel is encoded, of course, is not established; it might be an image, an abstract set of symbols, or anything else capable of regenerating the kernel sentence on demand.

In support of this schema-plus-correction hypothesis, one notes a strong tendency for *S*s to simplify the syntactic structure. Not only were kernel sentences easier to recall, but from Table 1 we can count 468 syntactic errors that (in terms of Fig. 1) involve responses nearer to the kernel than was the correct response, but only 380 errors in the opposite direction. (If we ignore the more or less natural confusions between *Q* and *NQ* and between *QP* and *NPQ*, this difference becomes even more obvious: 400 to 248.) Moreover, the nature of the errors in *K* is also suggestive; the great majority of them were simple omissions.

In his report of our preliminary data, Miller (1962) suggested that there are three syntactic "footnotes" that are remembered more or less independently. This hypothesis of independence, however, is not critical for the general hypothesis that *S* stores the information after analyzing it into its separate syntactic and semantic components. In particular there is one notable exception to the proposal that the three transformations might be encoded independently: *Q* and *NQ* are frequently confused, as are *PQ* and *NPQ*. Questions, both active and passive, are more likely than nonquestions to be recalled in the negative. Thus more often than we would expect on the assumption of independence, *Q* is recalled as *NQ*, and *QP* as *NQP*. This interaction between *N* and *Q* transformations is undoubtedly related to the fact that affirmative and negative questions mean the same thing (*Has the boy hit the ball?* vs. *Hasn't the boy hit the ball?*), whereas affirmative and negative declarative sentences mean very different things (*The boy has hit the ball* vs. *The boy hasn't hit the ball*).

Fortunately, however, independence of the recall of the various transformations is not essential for a schema-plus-correction type of hypothesis. The critical point is that the great majority of the errors people made consisted of sentences that could be derived from the correct sentence by omitting or applying syntactic transformations; it would not be possible to account for this fact by any theory of recall that neglected these syntactic operations.

Moreover, if one accepts the kernel sentence as psychologically simpler and, in some sense, closer to the way we understand the meanings of sentences, then we may also have a partial explanation for the fact, reported in numerous studies of thinking and concept learning, that negative information is harder to use than affirmative information. The difficulty may be due, at least in part, to the fact that negative sentences involve an additional syntactic transformation. The validity of this explanation might be tested by investigating the use of information expressed in passive sentences or in questions.

Summary

The recall of English sentences varying systematically in syntactic structure was studied by the method of prompted recall

with 80 *S*s. Analysis of the errors indicated that most of them were due to syntactical confusions. The hypothesis is advanced that *S*s analyze the sentences into a semantic component plus syntactic corrections when they learn them, and that this separation of semantic content from syntactic form is one reason that the general meaning of a message is generally so much easier to recall than its exact wording.

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(Received March 18, 1963)