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The Role of Semantic and Syntactic Constraints in the Memorization of English Sentences[1]

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It has been shown by Miller and Isard (1963) that the intelligibility of strings of English words depends, at least in part, on their conformity to linguistic rules known by the listener. Other things being equal, intelligibility is highest for meaningful grammatical sentences, lower for semantically anomalous (grammatical but meaningless) sentences, and lowest for ungrammatical strings of words. Apparently, both syntactic and semantic rules provide psychologically effective constraints on the number of alternative messages that a listener expects to hear. When strings of words follow these rules, perceptual processing is facilitated and intelligibility is increased.

If adherence to syntactic and semantic rules increases the intelligibility of strings of words, it might be expected that memorizing such strings would likewise be facilitated. Miller and Selfridge (1953) reported that the recall of strings of words improves as their order of approximation to the statistical pattern of English increases. Statistical approximations to English, however, do not distinguish between the syntactic and semantic factors that underlie the sequential contingencies. In the present experiment, strings of words were constructed in which semantic and syntactic rules could be violated independently. *S*s' performance in a free-recall type of learning situation was then compared for the various types of strings. We expected that, when syntactic and/or semantic rules were disrupted, the least disrupted strings would be most easily recalled, and that specific and predictable types of errors would occur in the recall of the disrupted strings. These expectations were confirmed by the experimental data.

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METHOD

Materials

The method of construction of meaningful grammatical sentences and semantically anomalous sentences has been described by Miller and Isard (1963), and thus will be treated here only briefly. Five normal sentences of five words each with identical syntactic structures (adjective–plural noun–verb–adjective–plural noun) were constructed. From these original sentences five more sentences were derived by taking the first word from the first sentence, the second from the second, and so on. The syntactic structure of these derivative sentences remained identical to that of the normal sentences, but, because of the word substitutions, the derivative sentences were semantically anomalous.

In addition, two other types of strings of words were derived. The first, which we shall call anagram strings, was constructed by taking each of the normal sentences and scrambling the word-order, each sentence being scrambled somewhat differently in order to avoid the possibility of *S*s noticing any pattern, with care being taken that none of the scrambled sentences was grammatical. Thus nothing was done to the semantic components of these sentences, but the normal syntactic structure was destroyed. Finally, strings of words which we shall call word-lists were similarly formed by scrambling

the word-order of the anomalous sentences. The word-lists preserved neither the syntactic structure nor the semantic components of the original sentences.

Five strings of each type were formed. Two sets of materials, each containing all four types of strings, were constructed. These materials are presented in full in the Appendix. It should be noticed that the words used are not in general high-frequency words in English. As Miller and Isard pointed out, high-frequency words have multiple syntactic and semantic roles which they can play, so that scrambling or substituting them is less likely to produce ungrammatical or semantically anomalous derivatives.

Procedure

Each group of four strings was recorded on magnetic tape by one of the experimenters (LEM). They were read at the rate of about 5 words in 3½ sec, with about 2 sec between strings. Since 5 trials were run, each group of strings was recorded 5 times, the order of the strings being varied from trial to trial according to a latin-square design.

The recorded strings were played to *S*s in a quiet room. On each trial *S*s listened to all 5 strings, then had 2 min in which to write them down in any order as accurately as possible. *S*s were requested to guess if they were uncertain.

Twenty-four groups of 4 *S*s were used. *S*s were Harvard and Radcliffe undergraduates and graduate students. Each group was tested on two different types of strings, one from each of the two sets of materials. Each of the four types of string from each set was given first to three groups and was then followed by one of the other three types from the other set. Thus, each of the 24 possible combinations of two sets of strings was presented to one group of 4 *S*s.

Results

There was a marked warm-up effect for all groups of *S*s from the first to the second set of materials learned. Since this effect was of secondary interest, and since the relative differences among the four types of test materials were essentially the same on both the first and the second tasks, the results of the same type of strings for the two sets were combined. The counterbalanced design of the experiment made such a combination possible.

Three alternative ways of scoring *S*s' performance were used; the results for each are given in Figs. 1–3. Figure 1 shows the median per cent of words correct on each trial for the four types of material. In order for a word to be correct, it had to be written as presented and in its correct position relative to the other words recalled in the string. Clearly, learning was most rapid for the normal sentences and most difficult for the word-lists. The curves for the anomalous sentences and for the anagram strings are almost identical.

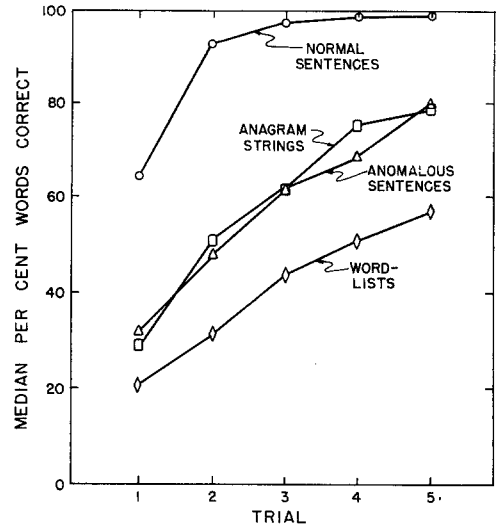

FIG. 1. Median per cent of words correct for each of the four types of strings over five trials. A word was counted as correct only if it appeared in its correct position in the string.

Figure 2 shows the median per cent of total words correct. That is to say, words counted as correct if they occurred together in a presented string, but regardless of the position in the string in which *S*s recalled them. These functions are similar to those of Fig. 1, except that the anagram strings here are slightly superior to the anomalous sentences. This difference is due to the fact that a relatively large number of inversions occurred in the responses to anagram strings.

Scores for complete strings recalled were, of course, lower than word scores, as Fig. 3 indicates. Normal sentences are far superior to the other three; word-lists are the lowest. With this method of scoring, however, ano-

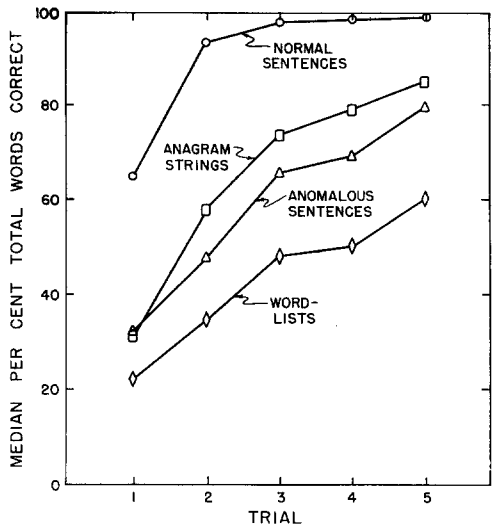

FIG. 2. Median per cent of total words correct for each of the four types of strings over five trials. A word was counted as correct regardless of its position in the string.

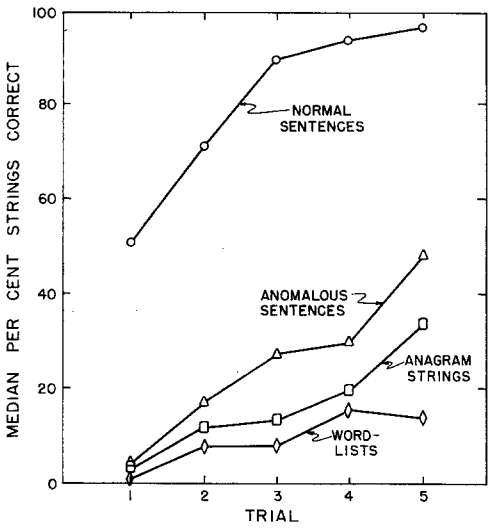

FIG. 3. Median per cent of complete strings correct for each of the four types of strings over five trials.

malous sentences were definitely better recalled than anagram strings.

Three types of errors in *S*s' responses for the five trials were analyzed: inversions, bound-morpheme errors, and intrusions. The results are summarized in Table 1.

Inversions of words within strings occurred most frequently in the case of anagram strings, rarely in the other three cases. They are somewhat more common to word-lists than to normal or anomalous sentences, and significantly so at each of Trials 2–5 (χ^2 for each $\geqslant 6.5$, $p < 0.01$). There is no significant difference in the frequency of inversions between the normal and anomalous sentences.

TABLE 1

MEDIAN NUMBER OF THREE TYPES OF ERROR FOR EACH *S* FOR THE FOUR TYPES OF STRINGS OVER FIVE TRIALS

String	Trial	Inversions	Bound-morpheme error	Intrusions
Normal sentences	1	0.15	0.75	0.19
	2	0.04	0.17	0.12
	3	0.02	0.13	0.05
	4	0.00	0.09	0.02
	5	0.01	0.06	0.06
Anomalous sentences	1	0.10	0.27	1.42
	2	0.07	0.30	1.09
	3	0.07	0.13	1.00
	4	0.04	0.25	0.83
	5	0.04	0.30	0.50
Anagram strings	1	1.39	1.61	0.42
	2	2.70	2.63	0.21
	3	2.59	2.90	0.17
	4	1.94	2.77	0.09
	5	1.15	2.50	0.10
Word-lists	1	0.08	0.63	0.83
	2	0.32	1.44	1.29
	3	0.30	1.64	1.43
	4	0.30	1.37	0.94
	5	0.25	1.61	0.90

Bound-morpheme errors refer to the omission or incorrect addition of prefixes and suffixes. The majority of these were omissions of the plural *–s*. Again, these errors are most frequent in anagram strings. They are also common to word-lists but are relatively rare in normal and anomalous sentences, except for the former on Trial 1.

The final type of error studied was intrusions. These concern the misplacing of words from one string to another in the group of strings being learned. Intrusions are most

common to the word-lists and anomalous sentences, and rare in normal sentences and anagram strings. They are most frequent in word-lists, but the difference is significant only with respect to anomalous sentences at Trial 1 ($\chi^2 = 5.44$, $p < 0.01$).

Discussion

It is clear that, in this experimental situation at least, syntactic and semantic structure facilitate learning. The role of the former has previously been studied by Epstein (1961, 1962), who concluded that the facilitation is apparently the result not of constraints which reduce the number of possible alternatives, but of some sort of "chunking" according to grammatical rules (see Miller, 1956). As mentioned above, constraints due to transitional probabilities do not distinguish between semantic and syntactic factors. Yet these two seem distinguishable on the basis of error scores.

The three types of error scores may be placed into two categories: semantic and syntactic errors. Intrusions can be considered as semantic errors, related to decisions as to which words may combine in a sentence, and thus occur most frequently in anomalous sentences and word-lists, where semantic rules are violated. Bound-morpheme errors and inversions can be considered as syntactic errors: the first related to grammatical tags, the second to word-order. Both occur most frequently in anagram strings and word-lists, where syntactic rules are violated. Apparently, therefore, these errors give support to the contention that syntactic and semantic rules have psychological as well as linguistic reality.

Figure 1 indicates almost no difference between the relative frequencies of correctly placed words for anomalous sentences and anagram strings; using a more lenient scoring method that ignores order, however, the scores (Fig. 2) for anagram strings are higher. It can be argued that the similarity between the two sets of scores is in line with the conclusion reached by Epstein. If the facilitory effect on learning of syntactic and semantic structure is due to chunking, then, for these strings at least, one would conclude that the *average* size of the chunks is the same in anomalous sentences and anagram strings. However, string scores (Fig. 3) show the anomalous sentences well above anagram strings. Thus, it would seem that the chunks formed in the recall of anomalous strings are more varied in length, more nearly "all-or-none," and are more consistent in the recall of anagram strings.

Summary

Ninety-six *Ss* learned normal sentences, anomalous sentences, anagram strings, and word-lists for five trials by the method of free recall. The results demonstrate a differentiation between semantic and syntactic factors and a facilitory effect of both on learning.

Appendix

The Two Sets of Materials Used in the Present Experiment

Set I

Original Sentences: Rapid flashes augur violent storms. Pink bouquets emit fragrant odors. Fatal accidents deter careful drivers. Melting snows cause sudden floods. Noisy parties wake sleeping neighbors.

Anomalous Sentences: Rapid bouquets deter sudden neighbors. Pink accidents cause sleeping storms. Fatal snows wake violent odors. Melting parties augur fragrant drivers. Noisy flashes emit careful floods.

Anagram Strings: Rapid augur violent flashes storms. Bouquets pink odors fragrant emit. Deter drivers accidents fatal careful. Sudden melting cause floods snows. Neighbors sleeping noisy wake parties.

Word Lists: Rapid deter sudden bouquets neighbors. Accidents pink storms sleeping cause. Wake odors snows fatal violent. Fragrant melting augur drivers parties. Floods careful noisy emit flashes.

Set II

Original Sentences: Furry wildcats fight furious battles. Respectable jewelers give accurate appraisals. Lighted cigarettes create smoky fumes. Gallant

gentlemen save distressed damsels. Soapy detergents dissolve greasy stains.

Anomalous Strings: Furry jewelers create distressed stains. Respectable cigarettes save greasy battles. Lighted gentlemen dissolve furious appraisals. Gallant detergents fight accurate fumes. Soapy wildcats give smoky damsels.

Anagram Strings: Furry fight furious wildcats battles. Jewelers respectable appraisals accurate give. Create fumes cigarettes lighted smoky. Distressed gallant save damsels gentlemen. Stains greasy soapy dissolve detergents.

Word Lists: Furry create distressed jewelers stains. Cigarettes respectable battles greasy save. Dissolve appraisals gentlemen lighted furious. Accurate gallant fight fumes detergents. Damsels smoky soapy give wildcats.

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