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The Prediction of Recall Patterns in Simple Active Sentences

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The present experiment proposed to show that information about the recall properties of a stimulus sentence is contained in the sentence-associations it elicits. Eighty-seven *S*s were presented 20 stimulus sentences, all grammatically equivalent to *The small boy hit the ball,* and were asked to give a grammatically identical sentence-association—the first sentence that comes to mind—for each. Another 40 *S*s were asked to recall the same 20 stimulus sentences. The recall probability of the modifier, actor, verb, or object in each stimulus sentence was inversely related to the variability, measured by informational uncertainty U, of the words used as the corresponding sentence part in the sentence-associations to each stimulus sentence. In general, the actor was best recalled and had the least variability in the sentence-associations; the modifier and object were intermediate in these respects; the verb was least recalled and had the most variability. In addition, individual differences of the stimulus sentences in recall were predicted from the Us. Evidence of immediate constituents in the stimulus sentences was found in contingency measures among the modifier, actor, verb, and object both in recall and in the sentence-associations.

A subject, when asked to do so, will give the first simple sentence that comes to mind as an association to a simple stimulus sentence. The purpose of the present experiment was to show how the structure of the eliciting stimulus sentence—as evidenced in the recall pattern of the sentence—could be predicted from information contained in such sentence-associations.

The approach is derived from an analysis of the perception of single patterns recently proposed by Garner (1962). According to his analysis, a person does not perceive a visual pattern as a single isolated item, but as one belonging to a set of patterns that are implied by the given pattern. This inferred set, itself a subset of all possible patterns, has properties which define some of the structural characteristics of the individual patterns belonging to it. Garner and Clement (1963), for example, have shown that the size of (or number of members in) the psychologically inferred subset to which a particular pattern of dots belongs shows a high negative correlation with the rated "goodness" of that pattern. That is, the better, the simpler the pattern, the smaller is the set of patterns to which *S*s infer it belongs. Garner has also asserted that recall should be easiest for the pattern with the smallest subset of psychologically equivalent patterns.

In the present experiment, Garner's analysis of patterns was extended to the recall of simple modifier-actor-verb-object sentences, that is, sentences grammatically identical to

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The small boy hit the ball. Each sentence was regarded as one pattern, drawn from the set of all possible modifier-actor-verb-object sentences, but belonging to, or associated with, a limited subset of this totality of sentences. In order to tap this associated subset, *S*s were presented a stimulus sentence, such as *The lazy student failed the exam,* and were asked to give the first modifier-actor-verb-object sentence that came to mind. The sentence-associations they gave—for example, *The smart girl passed the test* or *The industrious pupil passed the course* or *The brilliant boy studied the paper*—seemed primarily to be equivalent or schematically parallel to the stimulus sentence; only rarely were they continuation or sequentially related sentences. A set of such sentence-associations, then, fit Garner's definition of a pattern's inferred subset of equivalent patterns quite well.

The relation between the recall of a sentence and its associated set of sentences might be described as follows: At the time of presentation of a single sentence, the *S* learns not merely the stimulus sentence but also something about the whole subset of sentences associated with the stimulus sentence. In ordinary terms, this subset defines the "sense" of the sentence, the general class of situations the sentence fits; the subset is a special case of what Deese (1962) would call the associative meaning of the sentence. If the subset is large, that is, if the sense of the sentence is diffuse or ill-defined, the *S* has much to learn at presentation and, consequently, there is a lower probability that he will recall the subset. At the time of recall, it is often only the characteristics of the subset, the general sense of the sentence, that the *S* remembers. Since the stimulus sentence itself is the sentence best defined by the characteristics of this subset and is probably then recognized as the stimulus sentence, it is usually recalled verbatim. Other member sentences of the subset, however, should occur as intrusions in the recall of the stimulus sentence with some probability. For the comparison of the recall of a number of sentences, then, the size of the subset associated with each sentence should be inversely related to the ease of recall.

Although the present experiment was generated from notions about the size of subsets in the perception of patterns, the concepts of size and subset themselves cannot be applied to subject-generated sets of sentence-associations, since the number of sentences associated with a particular sentence is unlimited. The probability distribution of the sentences associated with a given sentence, however, can be determined, and some property of this distribution used as an analogy to the concept of the fixed size of a subset. Some stimulus sentences, for example, elicit a small number of high-probability sentences from a particular group of *S*s, whereas other stimulus sentences elicit a much larger variety of sentences, each of low probability of occurrence. Thus stimulus sentences differ in the degree to which *S*s agree in responding to them; that is, sentences differ in the amount of constraint they impose on elicited sentence-associations. The differences among stimulus sentences in amount of constraint imposed on their sentence-associations are functionally analogous to differences in size of the subsets which determine how patterns are perceived. To indicate the amount of constraint on the associations, therefore, the present experiment used the variability of the *S*s' sentence-associations to a sentence.

Thus the present experiment consisted of two parts: in the first part, sentence-associations to 20 stimulus sentences were collected from one group of *S*s; in the second part, the free recall of the same 20 sentences was required of a second group of *S*s. The variabilities within the appropriate sets of associations given by the first group were then correlated with the probability of correct recall in the 20 stimulus sentences.

Methods

The Stimulus Sentences. Twenty sentences grammatically identical to *The small boy hit the ball* were selected with some modifications from a large set of sentences written by Johns Hopkins undergraduate men; in every sentence both determiners were *the.* These *S*s were asked to write "ordinary sentences that people might use every day." The 20 stimulus sentences used were: *The present governor entered the primaries, The dark room scared the child, The hockey player disliked the call, The angry mob hanged the murderer, The lazy student failed the exam, The medical doctor cured the patient, The new pants fit the man, The bored student sharpened the pencil, The wide road spoiled the park, The mysterious box contained the bomb, The ancient poet wrote the verse, The needed rain brought the relief, The young policeman stopped the speeder, The dairy farmer painted the barn, The dark cloud filled the sky, The difficult problem distressed the boy, The sudden rain ended the game, The broken bulb shocked the man, The hot sun dried the mud, The noisy airplane destroyed the mood.*

Part I. Sentence-associations were collected from 100 high-school girls, ages 16 and 17; 13 *S*s were eliminated for not following instructions or completing the protocols.[2] The 20 stimulus sentences were given to each *S* on two mimeographed sheets in one of four randomizations, with one similar additional sentence placed first on each sheet. Each stimulus sentence was followed by a sentence with blanks (indicated by parentheses) in place of the modifier, actor, verb, and object. The *S*s were told to write the first sentence they thought most people would think of after reading the stimulus sentence. As associations, however, *S*s had to use modifier-actor-verb-object sentences which did not contain any of the content words of the stimulus sentence. An example was given using "The small boy hit the ball" as the stimulus sentence and "The little kid caught the fly" as the sentence-association.

From the set of sentence-associations to each stimulus sentence, the informational uncertainty measure $U = -\Sigma\ p_i \log_2 p_i$ was calculated for the set of words constituting each of the four sentence parts, that is, for the set of words used as modifiers, for the set of words used as actors, and so forth. Here p_i is the relative frequency of a particular word-type i occurring in that distribution ($\Sigma\ p_i = 1$); plural words were counted as identical to their singulars. The uncertainty U of the modifiers in the set of sentence-associations to a particular stimulus sentence, for example, indicates the variability or diversity of the modifiers suggested to the *S*s by the original sentence. The number of different word-types used as modifiers in this sample is an estimate of this variability (and correlates highly with the U), but U is also sensitive to the distribution of probabilities among the word-types (Garner, 1962). Thus 80 *U*s were calculated, one U for each of the four sentence parts in the set of sentence-associations to each of the 20 stimulus sentences.[3]

The strict application of Garner's analysis of patterns in terms of inferred subsets would require the uncertainty to be calculated on sentences taken as wholes. The number of sentences associated with a stimulus sentence, however, is an unlimited set; in fact, 87 *S*s gave 87 different sentence-associations to most of the stimulus sentences. Even the number of adjective-noun pairs, for example, in the sentence-associations to any stimulus sentence was too large for the calculation of any meaningful joint or contingent uncertainty measures. For this reason, only the simple *U*s indicated above were used in the present analysis; nevertheless, some contingent properties in the *U*s could be inferred.

Part II. Forty female clerks and typists at the Bell Telephone Laboratories were used as *S*s for free recall; all were high-school graduates, and most were between 18 and 21 years old.

The 20 stimulus sentences were supplemented by 20 dummy sentences, obtained from the same source as the stimulus sentences. All 40 sentences were given to each of the 40 *S*s. Each sentence was on a 5×8-inch card, and the cards were arranged in four groups of ten. The *S*s, in groups of three or four, studied each set of ten sentences, one at a time. An auditory signal allowed 10 sec of inspection of each sentence. Immediately after the 10th sentence of each set, *S*s were given as much time as they wanted to write down what they could remember of the previous 10 sentences. The instructions included: "Write down everything you can remember even if you remember only parts of sentences. If you have some idea what a sentence was about, you should write down your best guess of that sentence."

Because serial-position effects occur in the recall of 10 sentences, the critical sentences were placed in positions 2 through 6 in each group of 10; the dummy sentences were placed in the remaining five positions. The 20 stimulus sentences were counterbalanced over their 20 positions in a 20 by 20 Latin square in which each sentence followed each other

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[3] A computer program which calculated the *U*s was designed by Miss Esther U. Coke, whose assistance is greatly appreciated.

sentence in one sequence only. The dummy sentences were counterbalanced in the same way so that they could have no consistent effects on the stimulus sentences. Each of the 20 different sequences was given to two randomly chosen *S*s. The correct recall of the modifier, actor, verb, and object in the correct position was scored only on the 20 stimulus sentences; again, plurals were counted as identical to their singulars. The intrusion of outside words into the recalled sentences was also recorded.

Results

An analysis of variance of the correct recall of each sentence part for each stimulus sentence in each presentation position by *S*s showed that the probabilities of correct recall of the four sentence parts (shown in Table 1) differed significantly from each other, $F(3, 60) = 23.01$, $p < .001$. The actor was recalled significantly more than either the object or modifier; the object and modifier in turn were recalled significantly more than the verb. The 20 sentences differed from each other in mean probability of recall, $F(19, 380) = 2.50$, $p < .001$; the sentence by sentence part interaction was also significant, $F(57, 1140) = 2.23$, $p < .001$. The controls in the design showed that the position in the presentation of the stimulus sentences for recall affected the probability of recall, as was expected, $F(19, 380) = 2.03$, $p < .025$, but no effects were found attributable to the presentation sequences of the sentences.

In comparing the recall probabilities and the *U*s from the sentence-associations, one can think of two 20×4 matrices, in which the

Table 1

Mean Uncertainties and Mean Recall Probabilities of the Modifier, Actor, Verb, and Object

	Modif.	Actor	Verb	Object
Mean *U* (in bits)	4.88	4.53	5.11	5.03
Mean recall probability	.430	.491	.398	.446

Note. The *U*s and recall probabilities are means for the 20 stimulus sentences from Parts II and I, respectively.

20 rows are the 20 stimulus sentences and the four columns are the four sentence parts—the modifier, actor, verb, and object. The first matrix contains the 80 *U*s from Part I; the second, the 80 probabilities of correct recall from Part II. The variation around mean recall in the matrix of recall probabilities should be predicted from the matrix of *U*s.

The correlation between the 80 corresponding cells of these two matrices was —.45 But this correlation can be partitioned into three orthogonal correlations: one due to the sentences alone (by correlating the row marginals of the two matrices), a second due to the sentence parts alone (by correlating the column marginals), and a third due to the sentence by sentence part interaction (by correlating the row by column interaction effects of the two matrices).

The product-moment correlation of the row marginals of the *U* and recall probability matrices was —.56. That is, the mean uncertainty of the sentence parts within each sentence predicted the mean probability of recall within that sentence in a linear relation which was highly significant, $F(1, 380) = 14.78$, $p < .001$; the residual from the linear trend was not significant.

The correlation of the column marginals of the two matrices (shown in Table 1) was —.89. This linear relation between the mean *U*s and mean recall probabilities of the four sentence parts was highly significant, $F(1, 60) = 54.50$, $p < .001$, but the residual from this linear trend was also significant, $F(2, 60) = 7.26$, $p < .01$.

The correlation between the row by column interaction effects of the two matrices was —.20, a small but significant correlation, $F(1, 1140) = 4.92$, $p < .05$; the residual from linear regression was also significant, $F(56, 1140) = 2.21$, $p < .001$.

A slightly different analysis of the data brings out what is more usually considered grammatical structure, the relationships among the words (or morphemes) comprising a sentence. How the recall of one sentence part is contingent upon the recall of another sentence part, for example, can be represented in the intercorrelations of the recalls of the four sentence parts. The four-fold point correlation of the recalls of the modifier and actor for all 20 stimulus sentences and all 40 *S*s is a general measure of contingency between the modifier and actor in this particular selection of sentences. The complete set of such intercorrelations among the four sentence parts is given in Table 2. Notice that these correlations are all quite high—*S*s tended to remember sentences completely or not at all—and seem to differ from each other very little. The differences among them are important, however, since a Friedman two-way analysis of variance on the six correlations from each of the 20 stimulus sentences separately, considering the stimulus sentences as sampled, showed the differences to be highly significant, $\chi^2(5) = 31.1$, $p < .001$.

A somewhat analogous measure of contingency between the sentence parts in the sentence-associations is a correlation for the 20 stimulus sentences of the *U*s of one sentence part with the *U*s of another. For instance, if the *U*s of the modifiers and actors were highly correlated, this would indicate an interdependency or contingency between the modifier and actor in the sets of sentence-associations; that is, when the variability of the actor is high, the variability of the modifier must be high, indicating high covariation between what modifiers and actors were given in the sentence-associations. The intercorrelations of the *U*s of the four sentence parts for the 20 stimulus sentences are also shown in Table 2.

TABLE 2

INTERCORRELATIONS OF THE MODIFIER, ACTOR, VERB, AND OBJECT IN RECALL AND SENTENCE-ASSOCIATIONS

	Recall			
	Modif.	Actor	Verb	Object
Modif.		.843	.667	.734
Actor			.755	.813
Verb				.838
Object				
	Sentence-associations			
	Modif.	Actor	Verb	Object
Modif.		.140	—.073	.106
Actor			.374	.573
Verb				.793
Object				

Note. Each recall correlation is based on 40 *S*s' recall of 20 sentences ($N = 800$); each sentence-association correlation is based on the *U*s from 20 stimulus sentences ($N = 20$).

In order to show the relationships among the modifier, actor, verb, and object more clearly, one can derive patterns underlying the two sets of intercorrelations shown in Table 2 from a type of nonmetric factor analysis. Using only the rank order of the six correlations, one can place the four sentence parts in at least a linear ordering such that the distances between them in that ordering reflect the correlations between them, according to a best fit criterion developed by Shepard (1962) and Kruskal (1964). Thus the closer together two sentence parts are in this ordering, the more correlated, or interdependent, they are. The same underlying pattern reflected in both sets of intercorrelations was the following single ordering: Modifier-Actor-Object-Verb. This ordering shows the striking reversal of the verb and object from the spoken order of the words. That the actor and object are more closely related than are the actor and verb was indicated in the patterns of both recall and sentence-associations. (The probability that both linear orderings were identical by chance is .083.)

DISCUSSION

The structure of the simple sentences used in this experiment can be conveniently analyzed into two parts: (a) The properties—in both recall and sentence-associations—common to an active modifier-actor-verb-object sentence schema, and (b) the properties unique to each sentence.

The recall pattern of sentences grammatically identical to *The small boy hit the ball* was highly predictable from the sentence-associations; that is, the mean recall probabilities of the modifier, actor, verb, and object correlated highly with their respective mean *U*s (see Table 1). In the generalized sentence, the actor was the most potent single member of the sentence; it was the best recalled and in the set of sentence-associations had the least uncertainty. The modifier and object were intermediate in this respect; the verb was the least potent. In the experiments of Anderson (1963), Coleman (1965), and Gutjahr (1959), the recall pattern of the actor, verb, and object was the same as that found here. In a previous experiment (Clark, 1965) which required *S*s to write simple active sentences, the pattern of the *U*s of the actor, verb, and object was similar to the pattern in the present experiment. Apparently adding the modifier in this experiment did not greatly affect the patterns in recall and uncertainty of the actor, verb, and object.

In describing the grammatical structure of *The small boy hit the ball,* linguists might use immediate constituent analysis, parsing the sentence into a noun phrase (*The small boy*) and a verb phrase (*hit the ball*), both of which can be further subdivided (see Wells, 1947). Such an analysis is one formal way of describing how the parts of the sentence covary with one another. In the generalized sentence, for example, the modifier (*small*) and actor (*boy*) covary more closely than do the actor (*boy*) and verb (*hit*), since the modifier and actor belong to the same constituent at this level, but the actor and verb do not. The pattern of covariation described by immediate constituent analysis should agree with that present in the sentence-associations and should also predict the pattern of contingencies found in the recall data. In recall, the noun and verb phrases were clearly present. The modifier and actor were closely associated, or correlated, and so were the verb and object. The linear ordering derived from the recall intercorrelations, Modifier-Actor-Object-Verb, separated out these two constituents; in fact, the modifier-actor and verb-object correlations were the largest found in Table 2.

The Modifier-Actor-Object-Verb ordering, also derived from the intercorrelations of the *U*s, suggests that the covariation within the sentence-associations is the same as that described by immediate constituents, since the modifier-actor and verb-object units were left intact in this ordering. A further argument—since the present experiment included no sensitive measure of contingency in the *U*s—comes in conjunction with a previous experiment (Clark, 1965), which was designed to find the contingent effects of one sentence part with another in the *U*s for the general active actor-verb-object sentence schema. In the previous experiment, *S*s were asked to write simple sentences in sentence-frames in which an actor, verb, or object was given and in some sentence-frames in which nothing was given; such an arrangement, for example, allowed the comparison of the *U* of the object position when the actor was given with the *U* of the object position when the verb was given. Although the sentences used in the present experiment also included a modifier, the contingent effects in recall of the actor, verb, and object can be compared with the contingent effects in uncertainty of the actor, verb, and object from the previous data. The three comparisons allowed in the previous experiment (shown in Table 3) are completely consistent with the parallel comparisons in the present experiment.

There is an inverse relationship between recall probability and uncertainty. For example, the set of verbs is more constrained by the object being given than by the actor; in parallel, the recall of the verb is more probable if the object is recalled than if the actor is recalled. One could argue that the constraints in the *U*s in the actor-verb-object

TABLE 3
COMPARISONS OF CONDITIONAL UNCERTAINTY, FROM CLARK (1965), AND CONDITIONAL PROBABILITY OF RECALL, FROM THE PRESENT EXPERIMENT, OF ONE SENTENCE PART GIVEN ANOTHER

Uncertainties			Recall		
		Significance of difference			Significance of difference
$U(\text{act} \mid \text{vrb}) \cong U(\text{act} \mid \text{obj})$			$p(\text{act} \mid \text{vrb}) \cong p(\text{act} \mid \text{obj})$		
3.82	3.71	n.s.	.956	.959	n.s.
$U(\text{vrb} \mid \text{act}) > U(\text{vrb} \mid \text{obj})$			$p(\text{vrb} \mid \text{act}) < p(\text{vrb} \mid \text{obj})$		
4.50	4.25	.01	.774	.854	.001
$U(\text{obj} \mid \text{act}) > U(\text{obj} \mid \text{vrb})$			$p(\text{obj} \mid \text{act}) < p(\text{obj} \mid \text{vrb})$		
4.69	4.13	.02	.858	.959	.001

Note. The recall differences were tested by the sign test, $N = 40$.

sentence schema describe the same thing immediate constituents describe. More important, however, is that recall probabilities parallel uncertainties, and that this parallel holds for both simple effects and first-order constraints.

Besides conforming to a general grammatical schema, each sentence used in this experiment had its own unique properties. First, the mean recall probability of the sentence parts of each sentence was highly predictable from the mean U of the sentence parts in the set of sentence-associations to each sentence. Aside from the mean recall of each sentence, the variation within each sentence from the recall probabilities expected in the general sentence schema was also predictable from the Us of the sentence-associations.

In responding to the uniqueness of each stimulus sentence, the *S*s of Part I produced a particular set of sentence-associations to each one. The *S*s of Part II were then expected to give these sentence-associations, or parts of them, as intrusions in the attempted recall of each sentence. These intrusions did in fact occur. About 81% of the intrusions from the 40 *S*s were words found in the sets of sentence-associations to the particular sentences that *S*s were attempting to recall. This supports the notion that *S*s remember the distribution of associated sentences, the general sense of a sentence, when trying to recall a sentence, and that the sentence-association technique used in this experiment has sampled this associated distribution.

One can consider every sentence as closely associated with a narrow distribution of sentences selected from a large distribution of sentences of the same form. This narrow distribution can be tapped by the sentence-association technique. The constraints in each sentence can be inferred from the particular distribution of sentences associated with that sentence. Specifically, sentence parts are differentially constrained according to the variability in the corresponding distributions of sentence parts within the associated distribution of sentences: large variability implies little constraint. These constraints, viewed as arising both from a general sentence schema and from the unique properties of each sentence, correlate with recall; the more constrained the sentence part, the better is its recall. This result agrees with Garner's (1962) notions about sets of patterns, inferred subsets, subset size, and recall, even though Garner was concerned with well-defined, closed sets and not with probabilistic distributions, such as those found in distributions of sentences.

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