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Configural Properties in Sentence Memory[1]

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Two theories of human memory, Gestalt theory and associationism, are contrasted with respect to their predictions about the cued recall of sentences. The Gestalt theory, with its assumption of emergent properties, predicts that test probes which maintain the configural properties of the studied sentences should be superior to probes that do not. The associative theory, with its assumption of independent associations, is shown to yield just the opposite prediction. The associative theory is confirmed in Exps. 1 and 2, but Gestalt theory is supported in Exps. 3 and 4 where the *S*s were required to generate continuations to the sentence as part of the study task.

What is the structure of human memory? Historically, psychology has known two major theories on this subject which stand in profound opposition to one another. The first is associationism, dating back to Aristotle, which attempts to reduce memory to a set of base elements called ideas, words, sense data, or, more recently, memory nodes. Knowledge is encoded in the form of connections among the base elements. The structure of these connections is very simple and mechanistic; there are bonds or associations linking pairs of elements. In recent times, the naked associations have been clothed with labels for semantic relations (e.g., Quillian, 1969; Anderson, 1972; Rumelhart, Lindsay, & Norman, 1972), but even so, one is left with a rather simplistic structure for human memory.

The second theory is Gestalt or organizational psychology which proposes a strikingly different conception of human memory. Compared to associationism, it is a relative newcomer to the scene, receiving its first systematic formulation in Koffka's (1935) classic book. The Gestalters completely abandoned the associationists' attempt to reduce memory to a base set of simple ideas interconnected by a complex network of associations. Rather, it was proposed that the units of memory were variable and dependent on the dynamic laws of perception. The mnemonic structure depends upon the perceptual system because stimuli that are perceived as units will be stored as unitary traces. These traces are connected together in hierarchical systems (Kohler, 1947, p. 144) to comprise the total memory structure.

The point of this paper is not to review the data that can be marshalled for one or another point of view. Suffice it to say that on empirical grounds neither theory has the overwhelming advantage. Associationism applies most naturally when the material to be memorized is decomposable into units, such as words or nonsense syllables, and when that material has no meaningful structure. Modern interference theory is probably the best representative of a successful associationist theory. Gestalt (or organization) theory fares best when the material is just the opposite—rich in meaningful structure and not readily decomposable into simple units. Perhaps the success of mnemonic devices (e.g., Bower, 1970) is the best evidence for the Gestalt theory. Gestalt theory would claim that the best way to remember some new fact is to enrich it in a way that would transform it into a structure

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with a simple and stable organization. Mnemonic devices appear to work in this manner. On the other hand, associationism would seem to predict that elaborating the material with further information would only increase the number of associations and so make memorizing more difficult.

Anderson and Bower (1971) extended the contrast between associationism and Gestalt theory to the domain of linguistic material, using, for illustrative purposes, the Rumelhart, Lindsay, and Norman (1972) model which indicates how an associationist analysis might be given for sentences. They propose that a simple sentence can be decomposed into a set of associations between a relation (typically, the verb of the sentence) and a series of noun arguments, the cases governed by the verb in a Fillmore-type case grammar (see Fillmore, 1968). Figure 1 indicates how the sentence

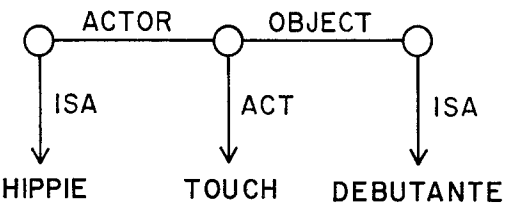

FIG. 1. The associative structure for the sentence. "The hippie touched the debutante" according to the Rumelhart *et al.* (1972) model.

"The hippie touched the debutante" would be analyzed by Rumelhart *et al.* Each association is labeled with the case relation to keep it distinct from the other associations. It is because of this labeling that we know Figure 1 represents "The hippie touched the debutante" and not "The debutante touched the hippie."

The reader should also note with respect to Figure 1 that this model involves a type–token distinction. That is, the nodes involved in encoding the sentence "The hippie touched the debutante" are not themselves the concepts "hippie," "touch," and "debutante." Rather, they are tokens of these concepts. These token nodes are connected by further associations (labeled with ISA and ACT relations) to the type nodes which represent the actual concepts. The type–token distinction provides efficiency in information storage and avoids ambiguities in the representation of information.

For present purposes, the important presupposition behind such analyses is that simple sentences can be decomposed into a network of separate and independent associations. In contrast, we (Anderson & Bower, 1971) argued that the Gestalt theory would predict that simple sentences are perceived and stored in a unitary fashion. However, our data were distinctly opposed to this hypothesis of unitary storage. For instance, it was found in prompted recall of sentences that *S*s tend frequently to remember simple sentences in fragments rather than overwhelmingly in all-or-none fashion. Incidentally, Anderson (1963) reports free recall data that also show considerable partial-sentence recall as the associationist theory would predict.

After our earlier experiment, we hit upon another experimental situation that would distinguish between the Gestalt and associationist theories. Moreover, we were convinced that in this new situation the outcome of the experiment would be favorable to Gestalt theory. The conflict between Gestalt theory and associationism in this situation is not concerned with whether the sentence was stored in many pieces (associations) or as a unit. The verdict of the prior experiment will be accepted on that issue. Rather the present issue concerns the independence of the associations. Rumelhart *et al.* (1972) did not explicitly commit themselves on this point, but without special assumptions, they seem committed to predicting that the separate associations in a trace are functionally independent. That is, reactivation of one association in a structure at the time of recall should not affect the state of the others. The Gestalt principle of emergence contrasts sharply with that independence assumption; a structure is not just the sum of its parts but

rather has new emergent properties that are dependent upon the configuration of the parts.

This principle of emergence applied to sentences has an obvious and intuitive consequence; namely, the information conveyed by a sentence is not just a combination of the information conveyed by its separate parts. New properties should emerge from the sentence because of the configuration of its parts. However, an associative account such as that in Figure 1 does not countenance emergent, configural properties. Figure 1 consists of the words (or perhaps, concepts) of the sentence and the associations between them, and that is all. It is this mechanical compounding of the parts to form a representation of the sentence that leads the associative theory to the counterintuitive predictions that will be tested in these experiments.

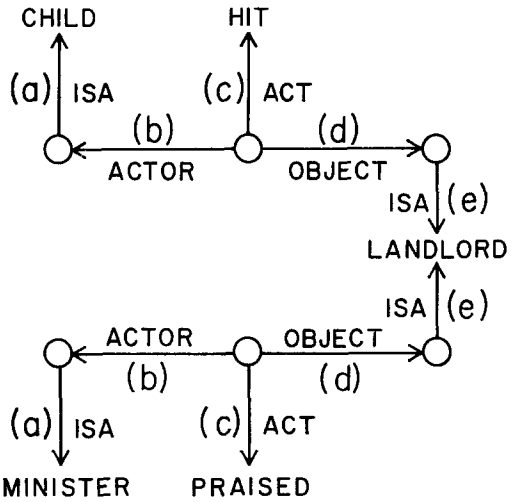

FIG. 2. The associative structure for the two sentences "The child hit the landlord" and "The minister praised the landlord."

Consider the associative structure that should develop after studying a pair of sentences like (1) and (2), which have the same direct object of the verb: (1), The child hit the landlord; and (2), The minister praised the landlord. The associative structure for these two sentences is illustrated in Figure 2. The crucial question of interest is how would a cue (prompt) such as frame (3) below compares with a cue such as frame (4) in terms of eliciting recall of the common object noun: (3), The child hit the_____; and (4), The child praised the_____. In frame (3), the subject-noun and verb are reproduced from the same study sentence, whereas in frame (4) they were selected from different study sentences. Since in both cases the subject and the verb have been associated with the same object-noun (i.e., landlord), there should be no ambiguity about what to recall in either case. The Gestalt hypothesis would predict that recall to frame (3) should exceed that to frame (4) because the acquired pattern of parts is maintained in (3) but destroyed in (4). Consequently, the emergent information should be maintained in (3) but not in (4). This prediction of the Gestalt hypothesis has been judged to correspond with intuition by every colleague or student we have consulted.

However, associative models lead to just the opposite prediction. The associations in Figure 2 have been labeled with probabilities to help explain the associative prediction. These labels denote the probabilities that the associations are effective at the time of recall. The probability of any one association being effective is assumed to be independent of the probabilities for any other. In the following, we shall be concerned with the probability that S recalls the object-noun when cued with various other parts of a sentence. We shall write these recall probabilities like conditional probabilities. Thus, $P(O|S)$, $P(O|V)$, $P(O|S_1V_1)$ and $P(O|S_1V_2)$ will denote the probability of object-noun recall given a recall test cue of, respectively, a subject, a verb, a subject and verb from the same studied sentence, and a subject and verb from different sentences of pairs like (1) and (2). An S_1V_1 test frame like (3), with S and V from the same sentence, will be called a *Same* cue; an S_1V_2 test frame like (4) will be called a *Crossed-over* cue.

By inspection of Figure 2, the following

equations are found to describe the recall probability for Same versus Crossed-over test frames:

$$P(O|S_1V_1) = abde + (1 - ab)cde \quad (5)$$
$$P(O|S_1V_2) = abde + (1 - abde)cde. \quad (6)$$

Subtracting (5) from (6) we have (7)

$$P(O|S_1V_2) - P(O|S_1V_1) = abcde(1 - de). \quad (7)$$

In words, recall to the Cross-over cue is predicted to exceed recall to the Same cue. Now the difference in Eq. (7) in favor of the Crossed-over cue may not be very large. For instance, if the probability for each association were .67, the difference would be only .073. However, even the prediction that these two test frames should elicit about equal recall is counterintuitive.

Recall of the object to the Crossed-over cue will succeed if either of two separate associative paths are intact, the one from the subject in the first sentence to the object or the one from the verb in the second sentence to the object. In contrast, for the Same cue the two associative paths, from the verb and from the subject, share two links in common, specifically the ones between the verb token and the object type. It is this difference which gives the Crossed-over cue the slight advantage in the associationist theory.

A second interesting prediction can be derived from Figure 2. It concerns the probability of successful object recall to a cue like frame (8), which only contains a subject-noun, and a cue like frame (9) which only contains a verb: (8), The child ... the_____; and (9), The ... praised the_____. The probabilities of recall for frame (8), $P(O|S)$, and for frame (9), $P(O|V)$, are: (10), $P(O|S) = abde$; and (11), $P(O|V) = cde$. The interesting observation is their relation to the probability of object recall to the Crossed-over cue, which is given in Eq. 12:

$$1 - P(O|S_1V_2) = [1 - P(O|S)][1 - P(O|V)], \quad (12)$$

or

$$P(O|S_1V_2) = 1 - [1 - P(O|S)][1 - P(O|V)]. \quad (12')$$

That is, the associative model predicts that the probability of nonrecall to the Crossed-over cue should equal the product of the probabilities of nonrecall to the subject-only cue and the verb-only cue. This follows because the Crossed-over cue is viewed as just an independent combination of subject and verb cues. This prediction can be shown to hold for almost any associative structure, not just the Rumelhart *et al.* (1972) model. Combining Eq. (7) with Eq. (12′) leads to the predicted inequality:

$$P(O|S_1V_1) \leqslant 1 - [1 - P(O|S)][1 - P(O|V)]. \quad (13)$$

Equation (7) and Inequality (13) rest on the assumption of any associative model that there is no further information in the Same cue than that contained in its parts, the subject and the verb. In contrast, if the Gestalt hypothesis is correct in its claim of emergent information, then both the inequality in (13) should be reversed and the Same cue should also be superior to the Crossed-over cue. Experiment 1 was designed to test these differential predictions.

One thing should be emphasized about these predictions of the associative model. That is, they are not at all dependent upon the particular graph structure configuration found in the Rumelhart *et al.* (1972) model. These predictions are compatible with basically any associative model which assumes that the memory trace for the sentence is a graph structure of nodes interconnected by independent associative links. Therefore, these experiments are testing a universal property of associative models in general rather than a prediction peculiar to the Rumelhart *et al.* diagrams.

EXPERIMENT 1

Method

Thirty-two pairs of simple subject-verb-object sentences having a common object noun were created.

The pairs were similar to the pair (1) and (2) above. The sentences were constructed so that the preexperimental associations between subject, verb, and object would be minimal, but also so that every combination of subject and verb with the common object-noun had a sensible interpretation. For each *S*, eight different pairs of sentences were randomly assigned to four testing conditions differing only in their recall cue: Condition S (subject-only cue), V (verb), S_1V_1 (subject and verb from same study sentence), and S_1V_2 (subject and verb from different study sentences). The sentences were randomly divided into two separate lists of 16 pairs or 32 sentences. The first 32 sentences were studied and tested once, and then the second 32 were studied and tested once. The order of presentation was random within the constraint that the second sentence of a pair had to appear exactly 16 sentences after the first. The order of testing was identical to the order of presentation, with the necessary exception of the Crossed-over cues. In this case the subject for the test cue came from the sentence that had occurred in the same ordinal position during study, but the verb of the test frame came from the other member in that sentence pair, which had occurred 16 sentences before or after in the study sequence. These study sentences and test cues were presented to the *S* on IBM cards, one sentence or test cue to a card. Each *S* had a deck of cards which he turned over one by one, paced by the *E* who signaled the appropriate time intervals. The *S* studied the sentences at a 6-sec rate and made written recall on the test cards at a 15-sec rate. For all cues the *S* was asked to recall only the object of the sentence. Before the experiment began, the exact nature of the experiment and the types of recall cues were described in considerable detail to the *S*s. It was emphasized that they should treat the two words in the Crossed-over test frame as independent cues for recall. The total experimental session lasted about 40 min.

Subjects. Forty-six *S*s (24 female, 22 male; 17–22 years in age) were tested in groups ranging in size from 1 to 10. The *S*s served in the experiment to partially fulfill a requirement in the introductory psychology course at Stanford University.

Results

One qualification should be mentioned about Eq. (12), which was derived in the introduction. The equation will only apply to data from individual subjects, not to average data. This is because it is reasonable to suppose that the probabilities *a*, *b*, *c*, *d*, and *e* will covary across *S*s (e.g., if some subjects are brighter than others). Consequently, the following inequality is to be predicted:

$$\left[1 - \sum_{i}^{n} \frac{P(\mathrm{O}|\mathrm{S})}{n}\right]\left[1 - \sum_{i}^{n} \frac{P(\mathrm{O}|\mathrm{V})}{n}\right] < \sum_{i}^{n} \frac{[1 - P(\mathrm{O}|\mathrm{S})][1 - P(\mathrm{O}|\mathrm{V})]}{n}. \quad (14)$$

That is, a different value will be obtained depending on how the value

$$[1 - P(\mathrm{O}|\mathrm{S})][1 - P(\mathrm{O}|\mathrm{V})]$$

is computed. A smaller value will be obtained if that quantity is computed from average values of $P(\mathrm{O}|\mathrm{S})$ and $P(\mathrm{O}|\mathrm{V})$ than if the quantity is computed separately for each subject and then averaged. It is only when the quantity is calculated by the latter method that Eq. (12) should hold.

Table 1 summarizes the results of the experiment. The probability of recalling the object to the four different cues is reported in the first four lines of Table 1. Each of the proportions in lines 1–4 is based on 736 observations. Lines 5 and 6 report the quantity used in Eq. 12 calculated by the group-average and individual-*S* methods. The probability of recall to the Same cue was less than the probability of recall to the Crossed-over cue, and less than the predicted probabilities in lines 5 and 6 derived from the recall to the subject-only and verb-only cues. Although the observed differences agree with the predictions of the associative hypothesis, they are quite small, less than 5% comparing the

TABLE 1

PROPORTION OBJECT RECALL—EXPERIMENT 1

1.	$P(\mathrm{O}\|\mathrm{S})$	.470
2.	$P(\mathrm{O}\|\mathrm{V})$	.292
3.	$P(\mathrm{O}\|\mathrm{S_1V_1})$	.579
4.	$P(\mathrm{O}\|\mathrm{S_1V_2})$	.611
5.	$1 - [1 - P(\mathrm{O}\|\mathrm{S})][1 - P(\mathrm{O}\|\mathrm{V})]$	.624[a]
6.	$1 - [1 - P(\mathrm{O}\|\mathrm{S})][1 - P(\mathrm{O}\|\mathrm{V})]$	.604[b]

[a] Computed from lines 1 and 2.
[b] Computed for each *S* and then averaged.

extreme numbers. (We had noted in the introduction that the recall difference between the Same and Crossed-over cues might be quite small.) Although these differences would not approach statistical significance, the result is surprising given one's initial intuitions. Also note that the quantity

$$1 - [1 - P(\mathrm{O}|\mathrm{S})][1 - P(\mathrm{O}|\mathrm{V})]$$

when calculated correctly (line 6) is very nearly equal to the average recall to the Crossed-over cue as Eq. 12′ would predict. In its total effect, this experiment greatly enhances the credibility of an associative account of sentence memory.

Experiment 2

Perhaps the Gestalt hypothesis failed in Exp. 1 because of the character of the sentences used. They were all sentences of the form of (1) and (2), chosen to have minimal preexperimental associations among subject, verb, and object. Thus, they were peculiarly arbitrary and perhaps not very meaningful out of a context. One might wish to claim in defense of Gestalt theory that those sentences lacked the emergent properties of sentences one ordinarily encounters. Therefore, Exp. 1 was repeated, but this time using simple sentences that appeared somewhat richer in meaning and made better contact with *S*'s previous experience. Examples are: (15), The Arab rode the camel; and (16), The cat chased the mouse.

In such sentences there is substantial probability that the *S* could guess the correct object when cued with the subject and the verb. Therefore, two plausible objects were assigned to each sentence to provide a measure of how much recall by guessing was occurring. For instance, the alternative objects for frames (15) and (16) were "horse" and "rat," respectively. By looking at the frequency with which the alternative was recalled in place of the correct object, we were able to devise a correction for guessing. However, this use of alternative objects brought with it a different technical difficulty: It is very difficult to construct a large number of pairs of subject–verb combinations as in sentences (1) and (2) which can both take either of two objects and which still yield highly meaningful sentences like (15) and (16). It is necessary to have pairs of such subject–verb combinations only if we insist on using Crossed-over cues. Therefore, we decided not to use Crossed-over cues in this experiment. The previous experiment had already indicated that the probability of recall to the Crossed-over cue could be estimated from the recall to the subject-only and the verb-only cues. (This result is also replicated in Exp. 3.) Therefore, with these specially constructed materials recall was tested only with the Same cue, the subject-only cue, and the verb-only cue. Data from these conditions will afford a test of the predicted inequality in Eq. 13, although they will not test Eq. 7 involving the Crossed-over cue.

Method

Forty-five highly meaningful sentences were constructed like (15) and (16) so that they could have either of two objects. For any sentence and for any *S*, the object was randomly selected from the pair of objects. Fifteen sentences were randomly assigned for each *S* to each of the following three recall-testing conditions: Same subject and verb, subject only, and verb only. Presentation order of the sentences was randomly determined for each *S*, and the order of testing the sentences preserved their order of study. As in Exp. 1, the sentences and test cues were presented to each *S* on his personal deck of IBM cards, one sentence or test cue to a card. The study rate was 5 sec per sentence and the test rate 15 sec. Recall of the object was requested for all cues, but unlike Exp. 1 *S* was also asked to recall the verb to the subject-only cue and the subject to the verb-only cue. The experiment lasted about 30 min. Thirty *S*s participated as partial fulfillment of a requirement in the introductory psychology course.

Results

For the subject-only cue, 30% of the verbs were correctly recalled; for the verb-only cue, 47% of the subjects were recalled. The crucial data, that for object recall, is summarized in Table 2. Column 1 of that table presents the object-recall data uncorrected for guessing. The

TABLE 2

PROPORTION OBJECT RECALL—EXPERIMENT 2

	Uncorrected	Corrected
1. $P(O\|S)$	.524	.484
2. $P(O\|V)$	.271	.244
3. $P(O\|S_1V_1)$	.671	.584
4. $1-[1-P(O\|S)][1-P(O\|V)]$	.653[a]	.610
5. $1-[1-P(O\|S)][1-P(O\|V)]$	.640[b]	.589

[a] Computed from lines 1 and 2.
[b] Computed for each S and then averaged.

data were corrected for guessing by subtracting from the number of objects correctly recalled the number of objects intruded which were alternative forms for the correct object. Since the choice between alternative objects for a particular sentence for a particular S was random, there was no possibility of biasing with this correct procedure. This correction reduces the "true" recall probabilities by 3 or 4% for the single cues, but a full 9% for the S_1V_1 cue, which constrains the guesses to a greater extent. The predictions of recall to the S_1V_1 cue (lines 4 and 5) from the S_1 and V_1 data are slightly below for the uncorrected data, and slightly above for the corrected data. As in Exp. 1, none of these predictions is significantly different from the observed object-recall to the S_1V_1 cue. Therefore, Inequality (13) has been preserved even with "meaningfully rich" sentences.

EXPERIMENT 3

A defender of the Gestalt theory might argue that the associative-fragment theory was favored in the preceding experiments because of an unnatural strategy of sentence processing induced by those procedures. That is, an S knowing that he is to be tested for verbatim recall would perhaps begin to process the arbitrary sentences and the test frames as serial strings of independent words rather than as meaningful wholes with emergent properties. If so, then the failure of the Same cue to exceed recall produced by the Crossed-over cue might be understandable. This argument suggests further that a different outcome would occur when procedures insure a more natural processing of the experimental sentences.

To achieve this end, Exp. 3 involved several changes in procedure. First, to avoid a verbatim encoding strategy, an incidental learning paradigm was used. Second, an incidental cover task was chosen that would bias S towards processing the sentences in a meaningful fashion. To this end, the S was asked to generate some logical continuation to the thematic content of the sentence. For instance, S might continue sentence (17) as (18): (17), The minister hit the landlord; and (18), The minister hit the landlord with a cross.

Method

The 32 pairs of subject-verb-object sentences of Exp. 1 were used in this experiment. However, there was a curious, and fortunately inconsequential, perturbation in the design of this experiment due to a failure of the randomization program: There was not a constant number of sentences assigned to each condition. A minimum of six different pairs of sentences were randomly assigned to each of the four testing conditions (subject-only, verb-only, Same, and Crossed-over) for each S. This accounts for the distribution of 24 pairs of sentences among the conditions. The number of the remaining eight pairs of sentences assigned to each condition was random. Consequently, between 6 and 11 pairs (rather than a constant eight pairs) were assigned to each condition for each S.

All 64 sentences were studied for one trial and then all were tested. The order of presentation was random within the constraint that the second sentence from a

pair appear 32 sentences after the first. Order of testing was the same as that of study (except for Crossed-over cues, as noted in Exp. 1). The sentences and test probes were presented on IBM cards as in the previous experiments. The *S*s proceeded at a 15-sec rate, writing their continuation to each sentence on each study card before turning it over. The *S*s were not constrained as to the grammatical structure of the continuation. They were only told that it should be short (no more than five words) and that it should relate to the original sentence. The *S*s were told that the purpose of the experiment was to "determine the distributional characteristics of the grammatical structures and vocabulary choices college students make when they produce constrained verbal responses." All *S*s appeared to accept this explanation since none admitted to anticipating a recall test. After going through all 64 sentences, the true purpose of the experiment was revealed and the types of recall cues were carefully explained. Then *S*s wrote their recall of the object-noun to the test frames, proceeding at a 15-sec rate. Forty-three *S*s participated in this experiment as partial fulfillment of a requirement in an introductory psychology course. They were tested in groups ranging in size from 1 to 10.

Results

The results are reported in Table 3, which should be compared with Table 1 for Exp. 1. It can be seen that the predicted proportion of recall for the Crossed-over cue (line 6) is again very close to the observed recall (line 4). However, in this experiment the Same cue elicits much better recall than does the Crossed-over cue (.724 vs .592). A correlated t test on the arcsin-transformed proportions shows that the difference between the Same and Crossed-over cue is significant [$t(43) = 3.80$, $p < .001$, two tailed]. Thus, it appears that the Gestalt prediction of the superiority of the Same cue to the Crossed-over cue is obtained if only the experiment is done right.

EXPERIMENT 4

It would be a mistake, however, to accept the conclusion of Exp. 3 too cavalierly. Perhaps the associationist hypothesis can be salvaged. A potential direction for its salvation becomes apparent if one examines critically the role of the cover task in Exp. 3. Essentially, it transformed the sentences that the *S*s were remembering from simple subject-verb-object constructions like that of Figure 1 to more complex constructions like that of Figure 3 which gives the structure of sentence (18), "The minister hit the landlord with a cross." The important thing to note is that the continuation (in this case "with a cross") is just encoded as another associative link from the main memory node of the structure. This means that the *S* might be able to recall the object if he were cued with the continuation.

Another observation to make along the way to salvaging the associative hypothesis is that the *S* might be able to recall this continuation given subject, verb, or both, without using the associative structure in Figure 3 that underlies memory of this sentence. That is, since he has already once generated the continuation

TABLE 3

PROPORTION OBJECT RECALL—EXPERIMENT 3

	Proportion	Sample size
1. $P(O\|S)$	.449	692
2. $P(O\|V)$	.277	676
3. $P(O\|S_1V_1)$	.724	706
4. $P(O\|S_1V_2)$	.597	678
5 $1 - [1 - P(O\|S)][1 - P(O\|V)]$	.602[a]	
6. $1 - [1 - P(O\|S)][1 - P(O\|V)]$	.591[b]	

[a] Computed from lines 1 and 2.

[b] Computed for each *S* and then averaged.

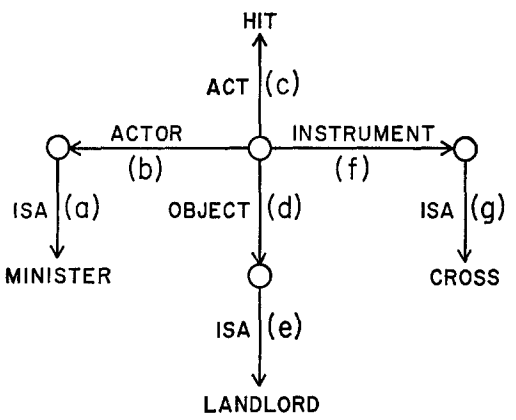

FIG. 3. The associative structure for the sentence "The minister hit the landlord with a cross."

spontaneously given the whole sentence, he could perhaps spontaneously generate it at recall given part of the sentence, even if there was not an intact associative path from the words in the sentence probe to the continuation. Hence, the continuation can serve as an additional cue for object recall and the availability of that cue does not just depend upon the intactness of the associative structure.

One further observation is required in the argument to salvage the associative hypothesis: It would seem reasonable to suppose that *S* would stand a much better chance of spontaneously generating the continuation if he were given both subject and verb from the same sentence than if he were given just one or the other. With the two, he could "triangulate" semantically what his continuation must have been. If these preceding arguments are correct, the advantage of the Same cue over the Crossed-over cue in Exp. 3 may be solely due to such spontaneous generation of continuations. Therefore, we decided to require the *S*s to try to recall their continuations in Exp. 4. If the preceding argument is correct, we should find a number of things in the data of this experiment. First, there should be much greater recall of the continuation to the cue of the subject plus the verb (Same cue) than can be predicted from cues that used just the subject or just the verb. That is to say, the following inequality should be observed:

$$P(C|S_iV_i) \geq 1 - [1 - P(C|S)][1 - P(C|V)]. \quad (19)$$

In this inequality, C stands for recall of the continuation. The exact opposite inequality would be predicted if the subject were only recalling the continuation by tracing associative paths that he had established during study from the subject and the verb. The reasoning behind this opposite prediction is identical to the reasoning that led to Inequality (13) with respect to object recall.

A second prediction that can be made from the notion of semantic triangulation is that across individual *S*s we should see a correlation between the magnitude of the inequality in (19) with respect to recall of the continuation and the magnitude of the corresponding inequality in (13) for the recall of the object. This result is to be predicted if some *S*s were able to take better advantage of the triangulating potential of the Same cue in retrieving the continuation. If so and if the higher than predicted recall of the object to the Same cue does depend upon the advantages of the Same cue for recalling the continuation, then we would expect those subjects who give higher than predicted recall of the continuation to do likewise with respect to recall of the object.

Third, according to the preceding argument it should be irrelevant whether the experiment is performed as an incidental or intentional learning task. The reason why the Same cue was superior to the Crossed-over is not that the *S*s were prevented from processing the sentences like serial strings by the incidental instructions, rather it is because they were generating continuations to the sentences. So, in this experiment we will have some *S*s study the sentences under intentional instructions and other *S*s study under incidental instructions, but have all *S*s generate continuations and all try to recall their continuations.

In this experiment we decided to forgo use of the Crossed-over cue. Experiment 3 confirmed the result of Exp. 1, that with subject-verb-object sentences, recall of the object to the Crossed-over-cue can be predicted from recall to the two single word cues. Therefore, it seemed unnecessary to complicate the experiment with a Crossed-over cue. Moreover, it is ambiguous what continuation *S* should recall to a Crossed-over cue.

Method

Thirty of the 32 pairs of sentences used in Exp. 1 and 3 were selected for this experiment. For each *S*, 20 sentences were randomly assigned to each of the three cueing conditions: subject-only, verb-only and Same. The 60 sentences were presented in a different random order for each *S*. Order of test was identical to order of study. As in the preceding experiments, the sentences and test cues were presented on IBM cards. *S*s had 15 sec for study in which they were to write short continuations to the sentences. The rate for recall was 25 sec per probe. In this time the *S*s recalled any words missing in the probe (verb and object to subject-only cue, subject and object to verb-only cue, and object to Same cue) and the continuation they had given to the sentence.

All 45 *S*s who participated in this experiment served to partially fulfill a requirement in the introductory psychology course at Stanford University. They were tested in groups ranging in number from 6 to 10. Twenty-six *S*s formed the intentional group and received instructions about the purpose of the experiment similar to those used in Exp. 1 and 2. The remaining 19 *S*s formed the incidental group and were given instructions similar to those in Exp. 3

Results

The first question to ask is whether there was any difference between the incidental and the intentional groups. Table 4 presents the relevant data for answering this question, the proportion object recall to the three cues used in the experiment. From the data in that table it would appear that the incidental *S*s were recalling uniformly better than the intentional *S*s. To test the significance of this effect and others, an analysis of variance was performed on the data in the first three lines of Table 4 using arcsin-transformed scores for each *S*. Of course, the differences among the three cues was highly significant [$F(2,86) = 43.86$, $p < .001$]. However, the difference between the incidental and intentional groups is only marginally significant [$F(1,43) = 3.99$, $p < .10$]. Therefore, the apparent difference in Table 4 between the groups may be due to a random difference in the constitution of the two groups of *S*s. In any case, it is clear that intention to learn had no facilitating effect It is sufficient that the *S*s process the sentence in a meaningful way. Of course, this result accords well with Gestalt theory which has always closely identified memorization of material with meaningful perception of the material. However, the result need not embarrass an associationist theory since such a theory also need not consider intention to learn an important factor.

TABLE 4

PROPORTION OBJECT RECALL—EXPERIMENT 4

	Intentional	Incidental
1. $P(O\|S)$	.490	.584
2. $P(O\|V)$	.305	.336
3. $P(O\|SV)$	.673	.763
4. $1 - [1 - P(O\|S)][1 - P(O\|V)]$	.646[a]	.724[a]
5. $1 - [1 - P(O\|S)][1 - P(O\|V)]$	.640[b]	.708[b]

Note: The proportions in the Intentional column are based on 520 observations, those in the incidental column on 380 observations.

[a] Computed from lines 1 and 2.

[b] Computed for each *S* and then averaged.

For present purposes, the important observation is that there is no interaction between group and cue, $F(2,86) = 1.92$. Hence, we may conclude that the superiority of the Same cue does not depend on the incidental instructions. Therefore, for subsequent analyses we will use Table 5, in which the data are pooled from the intentional and incidental groups. Table 5 presents the recall of the object and continuation to the three cues as well as the values of the computed quantities

$$1 - [1 - P(\mathrm{O}|\mathrm{S})][1 - P(\mathrm{O}|\mathrm{V})]$$

and

$$1 - [1 - P(\mathrm{C}|\mathrm{S})][1 - P(\mathrm{C}|\mathrm{V})].$$

According to the naive associationist account that does not allow for semantic triangulation, the computed quantities in line 5 should be greater than the recall to the Same cue in line 3. With respect to object recall, the difference in this experiment between the recall to the Same cue in line 3 (.711) and the computed quantity in line 5 (.666) is not as large as in Exp. 3. However, it is significant by a correlated t test [$t(44) = 2.33$, $p < .025$, two tailed]. Given that this difference replicates the finding of Exp. 3, we can be quite confident in it.

The interesting question is whether this inequality is also to be found in recall of the continuation. In scoring the continuations we used a somewhat liberal criterion. A correct recall of the continuation was one that was judged to have preserved the original meaning with no alteration, but it need not preserve the exact wording. It is clear in Table 5 that the proportion recall of the continuation to the Same cue in line 3 (.800) is much better than the proportion calculated from the recall to the single word cues in line 5 (.677). This difference is declared very significant by a correlated

TABLE 5

PROPORTION RECALL OF OBJECTS AND CONTINUATIONS—EXPERIMENT 4

	Object		Continuation	
1.	$P(\mathrm{O}\|\mathrm{S})$	.530	$P(\mathrm{C}\|\mathrm{S})$	.553
2.	$P(\mathrm{O}\|\mathrm{V})$	.318	$P(\mathrm{C}\|\mathrm{V})$	.323
3.	$P(\mathrm{O}\|\mathrm{SV})$	.711	$P(\mathrm{C}\|\mathrm{SV})$	.800
4.	$1 - [1 - P(\mathrm{O}\|\mathrm{S})][1 - P(\mathrm{O}\|\mathrm{V})]$	.680[a]	$1 - [1 - P(\mathrm{C}\|\mathrm{S})][1 - P(\mathrm{C}\|\mathrm{V})]$	.697[a]
5.	$1 - [1 - P(\mathrm{O}\|\mathrm{S})][1 - P(\mathrm{O}\|\mathrm{V})]$	.668[b]	$1 - [1 - P(\mathrm{C}\|\mathrm{S})][1 - P(\mathrm{C}\|\mathrm{V})]$	.677[b]

Note: 900 observations contribute to each of lines 1 to 3.

[a] Computed from lines 1 and 2.

[b] Computed for each S and then averaged.

t test, $t(44) = 6.70$. A large difference in this direction is required if we are to explain the inequality with respect to object recall in terms of semantic triangulation of the continuation. Also, as argued in the introduction to this experiment, there should be a correlation across Ss in the size of the two inequalities. That is, the following differences should be correlated:

$$P(\mathrm{O}|\mathrm{SV}) - [1 - [1 - P(\mathrm{O}|\mathrm{S})][1 - P(\mathrm{O}|\mathrm{V})]]$$

and

$$P(\mathrm{C}|\mathrm{SV}) - [1 - [1 - P(\mathrm{C}|\mathrm{S})][1 - P(\mathrm{C}|\mathrm{V})]]$$

The coefficient of correlation was .518, which represents a highly significant correlation in the predicted direction, $t(43) = 3.97$.

We may conclude from Exp. 4 that the associationist hypothesis has been salvaged from utter disaster. However, none of the results of Exp. 4 were sufficiently strong, in our opinion, to take away the new lease on life given to the Gestalt hypothesis by Exp. 3. All that Exp. 4 accomplished was to establish the plausibility of an alternate associationist

explanation of Exp. 3. Whichever theory is correct, the contrast between Exp. 1 and 2 and Exp. 3 and 4 clearly serves to indicate that sentences can have rather different mnemonic properties depending on the exact conditions of their study.

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