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# Representation and Retention of Verbatim Information

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Two experiments are reported that study subjects' memory for active and passive sentences. A reaction time methodology is used to measure subjects' memory for verbatim information about the sentence. It is shown that retention of the verbatim information displays the traditional short-term versus long-term discontinuity. The verbatim information can be interfered with by interpolation of meaningless strings of similar words. This is taken as evidence that the encoding of the verbatim information is similar to the encoding for a meaningless string of words. The various data can be accounted for by the ACT model (Anderson, *Language, memory, and thought*. Hillsdale, N.J.: Lawrence Erlbaum Associates, 1976) which represents both kinds of information in a propositional network.

Two important issues about memory concern: (a) how information is represented in memory and (b) the retention characteristics of the representations. These two issues are often interlinked, for instance, in discussions of levels of processing (e.g., Craik & Lockhart, 1972; Craik & Tulving, 1975; Kintsch, 1975; Hyde & Jenkins, 1973). In these discussions it is oftern argued that there are different levels of information representation and that deeper levels display better retention. There is a set of experiments (e.g., Anderson, 1974; Garrod & Trabasso, 1973; Keenan, Note 1; McKoon & Keenan, 1974; Olson & Filby, 1972; Smith & McMahon, 1970) on sentence memory that are thought to be relevant to these two issues. These are reaction time experiments that yield data indicating that two sorts of information are stored about a sentence: verbatim information about a sentence's exact wording and gist information about a sentence's meaning. These two kinds of information appear to have different retention characteristics with the verbatim information being less durable. This paper provides an experimental and theoretical analysis of the following two questions about the nature of the verbatim information: In what sense is the information representation different than the gist representation? In what sense are the retention characteristics of verbatim information different?

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Evidence for the existence of a distinct verbatim trace comes from a contrast defined on reaction times. Subjects are asked to judge whether or not a test sentence follows from earlier sentences that they have studied. The test sentence can either be exactly the same as a study sentence or a rewording of a study sentence. For instance, in the experiments to be reported, the test sentence was either the





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exact study sentence or involved a voice switch from active to passive or vice versa. Subjects are faster in verifying the test sentence if it exactly matches the study sentence. This advantage of an exact match is taken to reflect the existence of a verbatim representation of the information. By verbatim representation is meant a more or less direct encoding of word order. This advantage is much larger immediately following the study sentence than after a delay. This decrease in the difference is taken to reflect a loss of the verbatim information over time. The evidence for a gist or semantic representation independent of a verbatim representation comes from the subject's ability to make gist judgments (such as whether a test sentence follows from what was studied) even when they have lost their ability to make verbatim judgments (e.g. Anderson, 1974; Sachs, 1967; Wanner, Note 2). It appears that gist is better retained than verbatim information. Evidence for this assertion is the fact that subjects show virtually no loss in their ability to make accurate gist judgments but do lose ability to make judgments about word order.

These experiments have sometimes been interpreted (e.g. Anderson, 1974; Keenan, Note 1; Kintsch, 1975) as indicating that there are two distinct types of information representation. The gist is represented in terms of abstract propositions, whereas the verbatim information is a perceptual (nonpropositional) encoding of the physical sentence. An alternative view is that both sorts of information are encoded in abstract propositional format. Under this analysis verbatim information consists of propositions about the physical sentences, whereas the gist information consists of propositions about the referents of the sentences. We will not try to discriminate empirically between these two viewpoints since it can be shown (Anderson, 1976) that these two points of view (propositional vs propositional-plus-sensory) do not lead to different empirical predictions. However, the pure propositional interpretation would be preferred on grounds of parsimony if it can be shown that the two types of information display similar mnemonic properties.

A viewpoint (e.g., Clark, 1974; Olson, Note 3) that contrasts with either of these is that the evidence for verbatim information actually reflects memory for linguistic features of the sentence. For instance, it is argued that subjects may commit to memory information about the topic–comment structure of the sentence. Since an active test sentence mismatches a passive study sentence in its topic–comment structure, reaction times will be longer than if the study sentence had been active. Our intuitions from piloting these experiments conflict with this linguistic analysis. We feel that sometimes we are able to remember the exact wording of a sentence. These experiments will provide data relevant to this question.

The particular model we prefer, ACT (see Anderson, 1976), makes a clear commitment on these issues of representation. In ACT both gist information and information about the word structure of the sentence are stored in a propositional memory. The language processing scheme developed for ACT (see Anderson, Kline, & Lewis, in press) does not directly represent pragmatic information such as topic–comment structure. Such structure may influence how the sentence is processed but is not directly represented. It can only be inferred, either from the verbatim representation of the sentence of from the products of the sentence comprehension.

### *Nature of Information Retention*

These experiments are also relevant to questions about the retention properties of the memory system. One analysis of memory (e.g., Anderson, 1976; Anderson & Bower, 1973; Atkinson & Shiffrin, 1968; Glanzer, 1972; Shiffrin, in press; Waugh & Norman, 1965) sees memory as consisting of at least two stores, a short-term store (STS) and a long-term store (LTS). All information is initially put in STS where it can reside for a short while. During its residence in STS there is a probability of transfer to LTS where information remains relatively permanently. Probability of recall in a retention test reflects the probability of the information being in either STS or LTS. One of the typical sorts of evidence for this two-store model comes from retention tests that show rapid decay of information over short delays. However, over longer delays there is relatively little further loss of the information. The rapid initial loss is taken to reflect loss of information from STS and the eventual asymptotic retention to reflect the permanence of LTS.

This two-store model of memory has been incorporated into the ACT model with one qualification: STS is not conceived of as being physically distinct from LTS. Rather all memory is conceived of as a single propositional network. STS is that portion of the network which is currently in an active state. Information upon initial presentation is always represented in an active state. Upon its first deactivation (leaving STS) this newly encoded information may be lost. Therefore, in the ACT model, failure to transfer to LTS becomes failure to make the newly formed links permanent before deactivation occurs.

An alternative viewpoint (e.g., Craik & Lockhart, 1972; Kintsch, 1975; Melton, 1963; Murdock, 1972; Wicklegren, 1974) is that there are not different stores but rather different traces. The retention function cited above for the two-store model can be interpreted as reflecting two types of traces, a perceptual trace which decays rapidly and a semantic trace shich decays much less rapidly. The initial rapid loss of information is attributed to rapid decay of the perceptual trace. The asymptotic retention of information is attributed to the existence of the slowly decaying semantic trace. This alternate viewpoint will be referred to as the two-trace, one-store model.

The difference between these two models could be tested if we could obtain separate measures of the perceptual and semantic traces. The experiments to be reported here provide a measure which we think can be interpreted as a relatively pure indicant of the existence of a verbatim or perceptual trace. This is the reaction time advantage of an exact physical match in a semantic judgment task. The problem with recall measures, which are traditionally used to decide issues of retention, is that they reflect both semantic and perceptual information. If the two-trace, one-store model is correct there should be a rapid and complete loss of the advantage of an exact match. On the other hand, the ACT model and other two-store models predict an initial rapid decay of this indicant of verbatim information to an asymptotic level and little subsequent decay. That is, the advantage of an exact match should display the same retention characteristics as the more traditional recall measures. This is because verbatim information, like gist information, is encoded in a propositional network and subject to the same process of transfer to LTS. The only difference between gist and verbatim information according to this theory is in the probability of this transfer, with verbatim information less likely to be made permanent.

One thing that should be emphasized from the outset is that these experiments are not concerned with tapping the nature of language processing. They are somewhat artificial and we do not mean to imply that the processes occurring in these experiments are identical with the processes underlying normal sentence processing. The concern of this paper is with the issues of information representation and information retention. Sentences, with their independent dimensions of form and meaning, offer an ideal ground for exploring these issues.

## EXPERIMENT 1

The first experiment was an attempt to study more carefully the time course of the loss of verbatim information over a number of delays ranging from immediate testing up to delays of approximately 7.5 minutes. Previous experiments (with the exception of McKoon and Keenan, 1974, which will be discussed later) have not adequately addressed the basic question of whether verbatim information decays continuously over this time period, or whether there is a sudden drop-off in availability followed by asymptotic retention. These previous experiments have contrasted an immediate test with one delay. They have not mapped out a retention function over multiple delays.[1]

### *Method*

*Subjects.* Twenty-four subjects were recruited from the Yale student population. They were paid approximately $6 for an experiment that lasted about 3 hours. The experiment was broken up into two sessions separated by a 15-minute break.

*Material and procedures.* The sentences for this experiment were constructed form a basic set of class names of people (e.g., singer, lawyer, etc.) and transitive verbs. All sentences describe a person performing an action on another person. These names and verbs were recombined to create two lists of sentences, one list for the first half of the experiment and the other list for the second half. The sentences the subjects studied were written on 4 × 6-inch cards, and the test sentences for the reaction time phase of the experiment were presented on a screen in front of the subject.

Subjects studied and were tested in a Shepard–Teghtsoonian (1961) paradigm. That is to say, they studied a sentence, were tested with a sentence, and continued in a relentless cycle of study and test. Sentences were tested at various lags after original study. These lags were 0, 1, 3, 7, or 15 intervening test and study pairs. A test took approximately 15 seconds and the subject was given 15 seconds for study. Thus, in terms of time, these various lags were approximately 0, 30, 90, 210, and 450 seconds between the end of study and the beginning of test.

There are eight possible combinations of study and test sentences, which are illustrated in Table 1. These are produced by an orthogonal combination of three factors. There is the voice of the study sentence, active or passive (A or P); voice of probe sentence, active or passive (A or P); and truth of the probe sentence with respect to the study sentence, true or false (T or F). The eight conditions will be referred to by three letters denoting these three factors (e.g. APT would refer to the case where study sentence was active, test was passive and gist of sentence remains unchanged).

Combining the five lag conditions with the

[1] Garrod and Trabasso (1973) studied effects of various lags. However, all their lags were so short as to be within the traditional range of short-term memory.

TABLE I

THE EIGHT POSSIBLE COMBINATIONS OF STUDY AND TEST SENTENCES

| Condition | Study | Probe |
|---|---|---|
| AAT | The A verbed the B. | The A verbed the B. |
| APT | The A verbed the B. | The B was verbed by the A. |
| AAF | The B verbed the A. | The A verbed the B. |
| APF | The B verbed the A. | The B was verbed by the A. |
| PAT | The B was verbed by the A. | The A verbed the B. |
| PPT | The B was verbed by the A. | The B was verbed by the A. |
| PAF | The A was verbed by the B. | The A verbed the B. |
| PPF | The A was verbed by the B. | The B was verbed by the A. |

eight test conditions of Table 1 resulted in forty experimental conditions. Four observations were obtained per condition per subject: two in the first half and two in the second half of the experiment. Some filler sentences were needed to create all the desired lags. Including these filler sentences there were 103 study–test sequences in the first-half list and 110 in the second-half list. The exact sentences fulfilling each experimental condition were varied over subjects. As Table 1 shows, the same active or passive probe can serve any of four conditons depending on the sentence studied. Therefore, four different lists of study sentences were presented to different subjects and the list of test probes was kept the same.

The study–test sequence was as follows: The subject took a study card from a pile. She studied it for 15 seconds and then put it down. Her right hand rested on a center telegraph key between a true and a false key. Approximately 1 second after a verbal "ready" signal from the experimenter, a sentence was flashed on the screen before the subject, starting a timer. The subject moved her hand to hit the true or false key to indicate her response. The experimenter recorded the reaction time and response, and asked the subject whether the sentence originally studied was active or passive, also recording the subject's answer to this question. The experimenter gave the subject feedback as to the correctness of both the truth and voice judgments.

It was considered important that the subjects display high accuracy in their truth judgments. As an incentive to try to commit the sentences to memory, they were given 2¢ for each correct truth judgment they made. To motivate them to respond rapidly they were given up to an additional $3.00, depending on their mean speed of responding in the truth judgment task. So that they would not totally neglect the form judgment task they were paid an additional 1¢ for every correct form judgment.[2]

*Results*

The basic results of the experiment concern the speed with which subjects can judge the truth of sentences at various lags. Figure 1 presents the relevant data for trues and Figure 2 for falses. The mean verification time in seconds is plotted at each lag as a function of the voice of the probe and the voice of the input. The standard error of the reaction times in these figures is 134 milliseconds. Errors in judgments were excluded in computing mean reaction time. These varied from 3% at lag 0 to 7% at lag 15. The error data are reproduced in Table 2.

TABLE 2

Proportion Errors in Experiment 1

| | Lag | | | | |
|---|---|---|---|---|---|
| Condition | 0 | 1 | 3 | 7 | 15 |
| AAT | .000 | .010 | .073 | .052 | .073 |
| APT | .063 | .042 | .063 | .094 | .156 |
| AAF | .000 | .031 | .021 | .031 | .052 |
| APF | .031 | .052 | .073 | .125 | .063 |
| PAT | .042 | .021 | .083 | .052 | .031 |
| PPT | .000 | .021 | .031 | .073 | .010 |
| PAF | .021 | .052 | .010 | .125 | .104 |
| PPF | .073 | .073 | .052 | .063 | .063 |

As may be confirmed, an increase in error rate tends to be correlated with an increase in reaction time. We will focus our discussion on

[2] Some colleagues complained about this payoff scheme because it created an "artificial demand" on subjects to commit verbatim sentences to memory. Other colleagues have complained that the 2¢ versus 1¢ difference created a bias to favour gist encoding. We were not concerned with the relative amounts of gist versus verbatim memory which these criticsms reflect a concern for. We take it as established that under appropriate conditions subjects can display any amount of gist or verbatim memory desired. We simply wanted to insure that subjects would be motivated to try hard and to commit both types of information to memory. The higher payoff for gist was given because high accuracy was critical for the truth judgment aspect of the experiment.

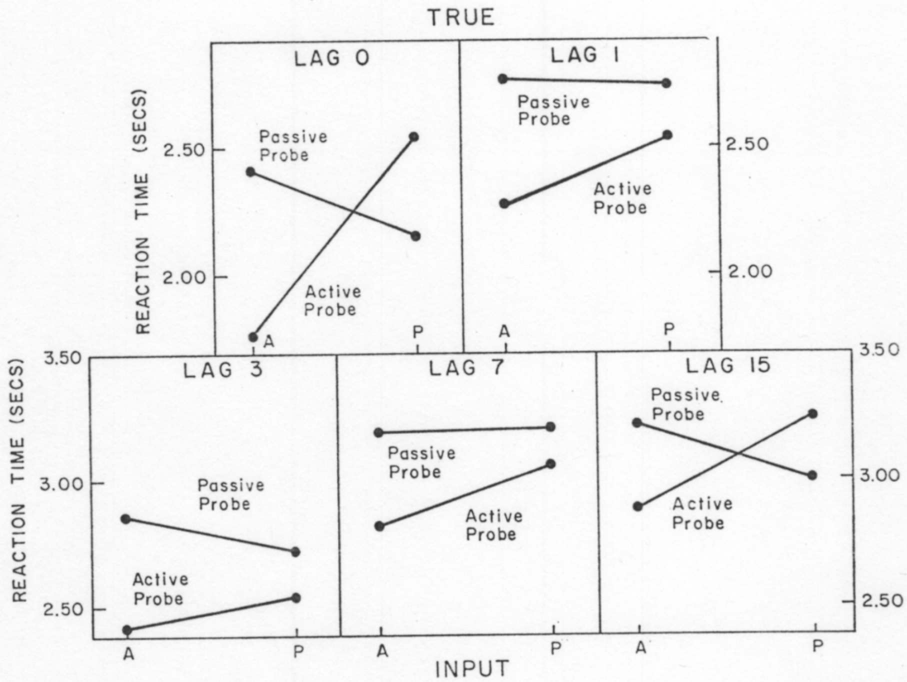


FIG. 1. Reaction times to true probes as a function of input voice, probe voice, and lag.

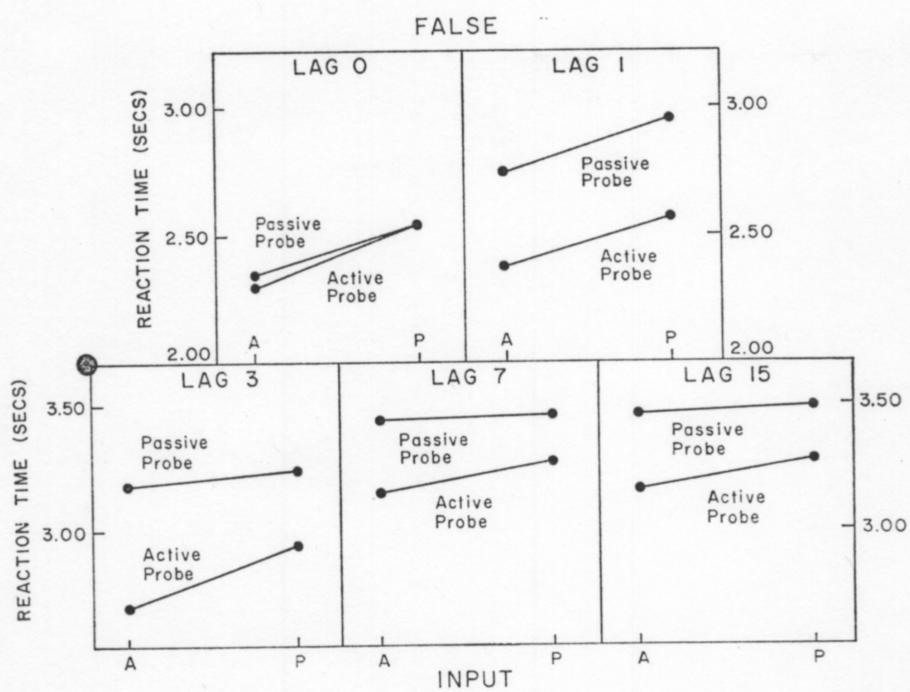


FIG. 2. Reaction times to false probes as a function of input voice, probe voice, and lag.

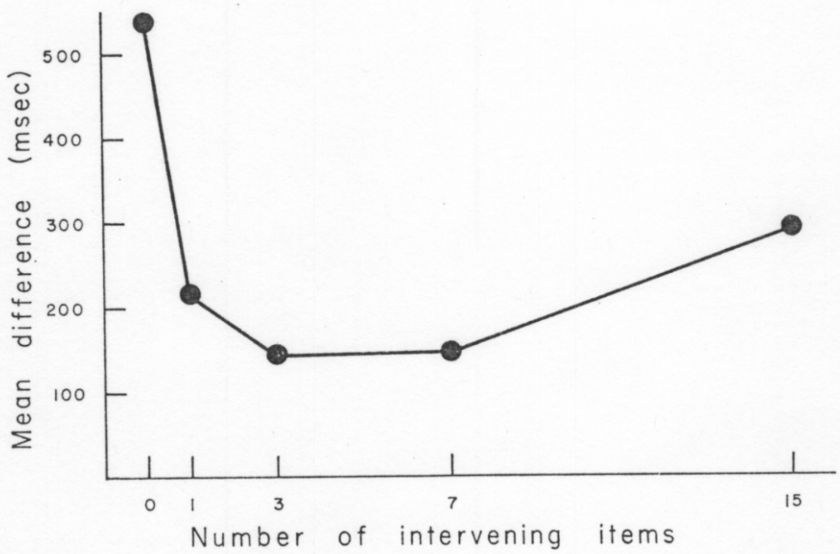


FIG. 3. The difference between true probes that matched the study sentences and those that did not. This is plotted as a function of lag to give an indicant of retention of verbatim information.

the reaction time data in Figures 1 and 2. First, there is a general increase in reaction time with delay. The mean reaction times (in milliseconds) are: 2318 at lag 0; 2624 at lag 1; 2842 at lag 3, 3195 at lag 7; and 3235 at lag 15. In Figure 1 there is an advantage of an exact match of study sentence and test sentence at each of the delays.

Figure 3 provides a more focused analysis of the advantage of an exact match. This involves a measure of the mean reaction time advantage gained by an exact match. This is defined in terms of the conditions in Table 1 as (APT + PAT − AAT − PPT)/2. As can be seen there is a relatively sharp drop-off in this measure from zero to one intervening item but little systematic change thereafter. A planned contrast that compared the size of this verbatim effect in the 0 lag conditions versus the mean of the times at other lags was significant, $t(897) = 2.16$, $p < .05$. The error term for this contrast was the subject-by-condition interaction. This result confirms the decreased availability of verbatim information at a delay reported by Anderson (1974). There is no significant linear trend in the verbatim effect from lags 1 to 15. Thus, the data in Figure 3 indicate that there is a loss of the verbatim trace over the first 30 seconds, but that if the trace survives this interval there is no further perceptible decay.

The accuracy of the form judgments was quite high. Subjects were 96% accurate at lag 0 and averaged 84% accuracy on delay tests. This is considerably higher than has been reported in other experiments (e.g. Anderson, 1974; Sachs, 1967; Wanner, Note 2), perhaps due to the incentives added for making form judgments. It seems that form judgments in this experiment depended on much more than just memory for a verbatim representation of the sentence. Subjects in these experiments report resorting to other devices to remember information about sentence voice. For instance, one subject reported imagining that the participants of active sentences were black while the participants of passive sentences were white. Apparently, subjects are using such auxiliary bases as well as the verbatim trace to make voice judgments. Bregman and Strasberg (1968) also report subjects using such encoding strategies to aid their verbatim memories. It is for this reason that we have concluded that the form recall in this experiment is not a useful indicant of the existence of verbatim information.[3]

*Conclusions from Experiment 1*

Figure 3 presents in the clearest form the data that Experiment 1 was designed to obtain. It plots advantage of an exact match as an indicant of the availability of verbatim information. This plot is more consistent with a one-trace, two-store model like ACT than the two-trace, one-store model. The two-store model predicted a sharp drop in availability of verbatim information when the duration of STS was exceeded and asymptotic retention after this. The one-store model predicted continuous decay of the verbatim information. The one-store model could account for the retention curve in Figure 3 by assuming that a number of traces underlie the verbatim information, a rapidly decaying trace producing the initial drop-off and a slow decaying trace giving the asymptote. However, this proposal seems implausible since it is difficult to give an account of what the different traces might be. It is also contrary to the frequent interpretation (e.g. Anderson, 1974; Kintsh, 1975; Keenan, Note 1) that the advantage of an exact match reflects the existence of a single perceptual trace.

## Experiment 2

Experiment 1 indicates a verbatim representation of the sentence which, if it survives the first 30 seconds, endures quite well. The next experiment was done to further explore the retention of that verbatim representation. In particular, we wanted to see what sort of intervening activities might interfere with its retention. It is frequently found that to-be-remembered material is maximally interfered with by similar intervening material. It seems reasonable that verbatim information in memory should also be subject to an interference-by-similarity principle. Therefore, by finding out what intervening material interfered with the verbatim information, we would be able to determine what this verbatim information is similar to and thus gain information about the nature of the representation. In particular, we wanted to see if the verbatim information can be interfered with by interpolation of meaningless word strings composed of the same words as the study sentence. If this can be displayed, it would be evidence against the position reviewed earlier that the advantage of an exact match depends on retention of semantic information such as topic–comment structure.[4]

*Subjects*. Twenty-three subjects were recruited from the University of Michigan subject pool. They were paid $4.00 for 2 hours of participation.

*Material and procedure*. The experiment was run using an IBM 1800 computer interfaced with five TV screen display stations. There were four conditions of delay: *immediate*, *math*, *similar*, and *different*. The sequence of events in an immediate condition was as follows:

(a) Any previous information was erased from the screen. The word STUDY appeared on the screen with a sentence presented below it. The subject was instructed to commit the sentence to memory in a meaningful fashion.

[3] Note in saying this we are using "verbatim information" to refer to a direct encoding of sentence word order. We are not denying that subjects may have information about word order in these auxiliary encodings. However, these encodings only contain verbatim information indirectly and cannot be used as a basis for truth judgments. Moreover, the auxiliary encodings are not the perceptual traces that we wanted to tap in evaluating the two-trace model of retention.

[4] It has been suggested that the encoding of the topic–comment structure would consist of words and so could be interfered with by interpolation of meaningless word strings involving the same words. However, the topic–comment structure is an encoding about the concepts or meanings corresponding to the words, not the words themselves. One would not expect that studying meaningless word strings would interfere with information attached to concepts. For instance, we would not expect (and did not find) interference with memory for the sentence's meaning.

The sentence remained on the screen for 15 seconds.

(b) After the 15-second study period, the screen was erased. Then the word TEST appeared on the screen with a sentence below it. The subject's task was to judge the truth of the test sentence given the study sentence. The subject's right and left index fingers rested on buttons indicating true and false, respectively. She pressed one of the two buttons to indicate her response. Her response was recorded as was the reaction time from presentation of the test sentence to the button press.

(c) The button press caused the screen to be erased and feedback put on the screen for 2 seconds indicating whether or not the subject was correct in her truth judgment.

(d) The question "Was the original sentence in the active form?" appeared on the screen. The subject indicated her response by pressing one of the two buttons, the right button for *yes* and the left for *no*. Her response was recorded as was the reaction time from presentation of that question to the button press.

(e) The button press caused the screen to be erased and feedback was presented for 2 seconds indicating whether or not the subject was correct in her voice judgment.

The math, similar, and different conditions involved this same sequence of events except that 30 seconds of intervening activity were interspersed between study (part a) and truth judgment (part b). This 30 seconds is approximately equal to the one-lag condition of Experiment 1. Experiment 1 suggested that 30 seconds exceeds the span of STS. The various types of trials were intermixed and a subject had no way of knowing during the study phase (part a) whether the trial would involve immmediate, math, similar, or delay testing. Thus, the subject studied the sentences in the same way in all conditions.

In the math delay, subjects spent the 30 seconds verifying the correctness of simple equations of the form $x + y = z$, where $x$ and $y$ were two-digit numbers. The procedure in the similar delay was more complicated but it can be described by the following algorithm:

(i) A *target string* was presented consisting of the subject, verb, and object from the study sentences plus the words *the*, *was*, and *by*. These six words were randomly ordered to compose the target string. Thus, if the subject had studied *The boy hit the girl* or some other sentence involving *boy*, *hit*, and *girl*, she might see the target string *boy the girl by was hit*. This string was presented for 5 seconds.

(ii) The previous string was erased and the subject was presented with another string that was either identical to the target string or different only in having two words reversed. The subject's task was to indicate by button press, *yes* or *no*, whether or not this string was identical to the target string.

(iii) If the subject was correct the algorithm returned to (ii) to test another string. If she was incorrect the algorithm returned to (i) to give the subject 5 more seconds study of the target string.

The procedure in the different delay was identical to the similar delay except that the target string was composed from six words entirely unrelated to the study sentence.

It was assumed that the interpolated task in the similar and different delay conditions would force subjects to attend to and encode information about the order of the words in the target strings. In the similar delay condition where the same words were used as in the study sentence, this interpolated activity should provide considerable interference to memory for the surface order of the words in the sentence. These should not be such interference in the math or different delays.

For each of the four delay types (immediate, math delay, similar delay, and different delay) sentences were used which realized all of the eight test conditions used in Experiment 1 (Table 1), so that in all there were 32 experimental conditions. Each of the 32 conditions was tested once in each of four successive blocks of trials which were separated by 5-

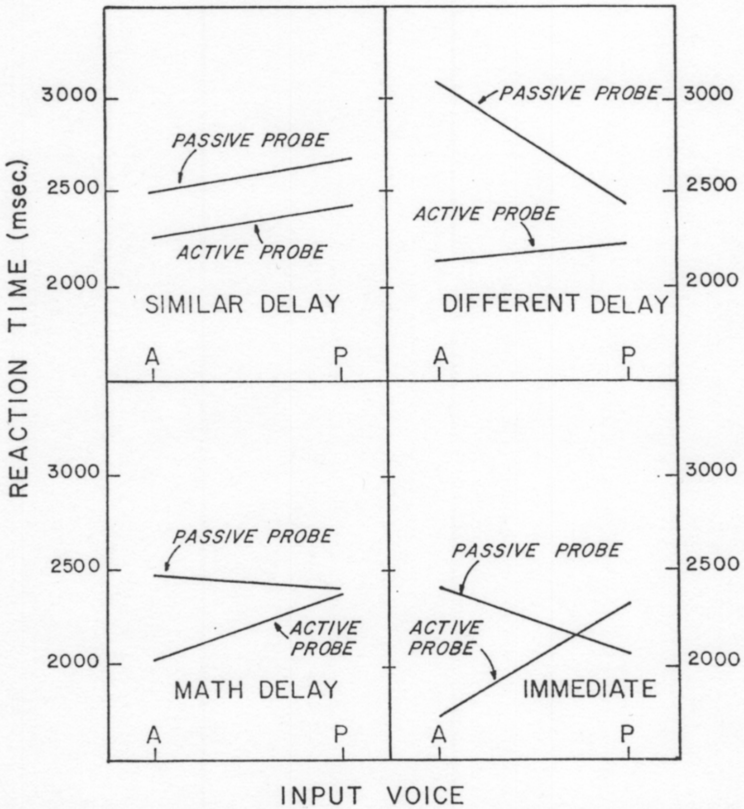


FIG. 4. Reaction time to true probes in the various retention conditions of Experiment 2.

TABLE 3

CRITICAL CONTRASTS THAT MEASURE VERBATIM EFFECT AND STANDARD ERROR OF THESE CONTRASTS

| | Similar | Different | Math | Immediate |
|---|---|---|---|---|
| 1. Form interaction<br>Reaction time<br>(standard error = 120 msec) | −2 msec | 389 msec | 208 msec | 480 msec |
| 2. Form interaction<br>Accuracy<br>(standard error = .019) | .027 | .065 | .060 | .076 |
| 3. Form judgment<br>Reaction time<br>(standard error = 47 msec) | 1785 msec | 1594 msec | 1629 msec | 1512 msec |
| 4. Form judgment<br>Accuracy<br>(standard error = .012) | .879 | .871 | .886 | .921 |

minute breaks. The 32 sentences for each block were randomly constructed from lists of 64 nouns and 32 verbs.

To keep subjects motivated they were given points for their speed and accuracy in both the main sentence judgment task and on the interpolated tasks. These points were displayed as feedback after each trial. However, in contrast to Experiment 1, subjects were not paid according to number of points earned.

### *Results*

Figure 4 displays the reaction times to a true probe in the four delay conditions of the experiment. The standard error of the reaction time means (based on the Subjects × Conditions interaction) is 20 milliseconds. Interest focuses on the advantage of an exact match. Row 1 of Table 3 reports for each condition the value of the contrast, (APT + PAT − AAT − PPT)/2, which measures the advantage of an exact match. Statistical analysis indicates that there is significant variation among these four contrasts, $F(3, 682) = 3.14$, $p < .05$. The value of this contrast is significantly larger in the immediate condition than it is in the average of the three delay conditions, $t(682) = 2.03$, $p < .05$. The value of this contrast is also significantly less in the similar delay than the average of different and math delays, $t(682) = 1.93$, $p < .05$. There is not a significant difference between different and math delay, $t(682) = 1.23$, $p > .10$. The fact that the contrast is smaller in the similar delay than other delays is predicted by the two assumptions that (a) memory for word order is what produces the advantage for an exact match and (b) the similar interpolated material interferes with memory for word order.

Table 3 contrasts a number of other measures under the four delays. Row 2 looks at the (APT + PAT − AAT − PPT)/2 contrast defined on the percentage of correct truth judgments. As would be predicted, this contrast is least in the similar delay condition. There is not, however, any overall significant variation among the conditions on this measure. A test specifically contrasting the similar delay with the different and math delay is only marginally significant, $t(682) = 1.51$, $p < .10$. Another prediction of the assumption of a reduced verbatim trace in the similar condition is that subjects should be less rapid and accurate in their judgments about the form of the sentence. Subjects were asked to recall if the original sentence had been active or passive after making their truth judgment. As row 3 indicates subjects do take longer to make this judgment in the similar delay. The overall variation in these form judgment times is highly significant, $F(3, 682) = 5.93$, $p < .005$ and the mean time in the similar delay is significantly longer, $t(682) = 3.02$, $p < .005$, than the average of the different and the math delay. This indicates that subjects are being prevented from using a verbatim trace for form judgment by the interpolation of an interfering task. Row 4 presents the overall accuracy of these judgments. There is significant overall variation in these accuracies, $F(3, 682) = 3.49$, $p < .05$. However, the accuracy in the similar condition is essentially identical to the accuracy of the other two delays (.879 vs .878). The significant variation in accuracies reflects the better accuracy in the immediate condition in contrast to all the delays (.921 vs an average of .878). The reaction time data (rows 1 and 3) do indicate a significantly greater loss of the verbatim trace under similar delay. The accuracy data (rows 2 and 4) are less conclusive. This difference between the accuracy and reaction time data is taken to reflect the greater sensitivity of the reaction time data to the existence of a verbatim trace.

This experiment supports the assumption that the verbatim information is encoded as information about word order (in contrast to other possible encodings such as topic–comment). It also indicates that the information can be interfered with. A principle of interference for semantic information has been displayed many times in other research (for a review, see Anderson, 1976, Chap. 8). The fact that a similar interference principle holds for verbatim information is consistent with the claim that the verbatim and semantic information are encoded in the same representational medium, for example, a propositional representation as is the case with ACT.

## Conclusions and Other Related Research

These experiments support a number of assumptions of the ACT model. These are the claim that there are two states of memory representation, a short-term transient state and a more permanent long-term state; the claim that subjects do retain, with some significant probability, a verbatim trace of the sentence; and the claim that this trace is encoded in propositional network form. It is possible to conceive of other theories that make these assumptions and other theories that could predict the results of these experiments by other assumptions. Therefore, the results of these experiments may well have significance beyond the ACT model. However, the ACT model does provide one framework within which to perceive the significance of these experiments.

There is one experiment which might appear to be at odds with the results and conclusions of our experiments. McKoon and Keenan (1974) report an experiment that tested for the existence of verbatim trace at various delays. Subjects read paragraphs and then had to verify sentences immediately after the paragraph, after a 30-second delay, after a 20-minute delay, and after a 2-day delay. They contrasted verifying sentences which were explicitly stated (a verbatim match) versus sentences that had to be inferred to understand the story (a nonverbatim match). There was a significant advantage for verbatim matches in the two shorter delays but not in the longer two. This result might seem to be the opposite of the result in Experiment 1, which was that there is a drop-off in the size of the verbatim effect from an immediate test to a delay test and no further decay. However, it should be noted that our "immediate" tests were immediate than those of McKoon and Keenan. In their immediate test a number of sentences in the paragraph intervened between presentation of the target sentence and its test. So, in our terminology all of their conditions would be "delay" tests. Also, their evidence is weak that the verbatim effect decays with time. They found significant verbatim effects at short delays and nonsignificant effects at longer delays, but did not show that the effect at the longer delay is significantly less than at the shorter delays.

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