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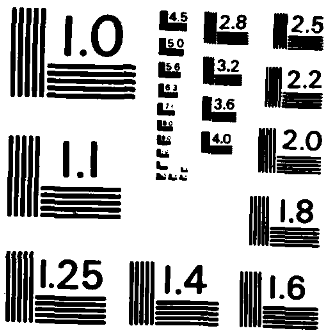
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Beyond Associations:

Strategic Components in Memory Retrieval

Lynne M. Reder

Carnegie-Mellon University

Technical Report No. ONR-85-3

October 3, 1985

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There are two dominant approaches to understanding human memory, one in the tradition of Ebbinghaus, the other in the tradition of Bartlett. The former approach views learning as the formation of associations, while the latter views memory as the process of reconstruction of fragments based on prior knowledge. These positions are often considered antithetical: Ebbinghaus was concerned with "laws" of memory and tried to control for prior knowledge; Bartlett was concerned with how our world knowledge interacts with learning and memory. This paper argues that one can collect data that supports either position because people can adopt one of several memory strategies. Data are reviewed that illustrate that the same knowledge structure can produce dramatically different results, depending on the strategies that operate on that structure.

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Abstract

There are two dominant approaches to understanding human memory, one in the tradition of Ebbinghaus, the other in the tradition of Bartlett. The former approach views learning as the formation of associations, while the latter views memory as the process of reconstruction of fragments based on prior knowledge. These positions are often considered antithetical: Ebbinghaus was concerned with "laws" of memory and tried to control for prior knowledge; Bartlett was concerned with how our world knowledge interacts with learning and memory. This paper argues that one can collect data that supports either position because people can adopt one of several memory strategies. Data are reviewed that illustrate that the same knowledge structure can produce dramatically different results, depending on the strategies that operate on that structure.

There are two strong traditions within the contemporary field of memory research, one belonging to Bartlett (1932) and one to Ebbinghaus (1964). The Ebbinghaus tradition is best characterized by its rigor, precision and attempts to uncover invariants in the memory system. His development and use of the "nonsense syllable" reflect his attempts to control for the influence of prior knowledge on list learning. The Bartlett tradition, started a half-century after Ebbinghaus, is quite complementary in its perspective. There is less focus on precise memory "laws", and more concern with how prior, world knowledge interacts with learning and memory.

An important component to Ebbinghaus' theory of memory is the formation of associations, direct and remote; learning is essentially the formation of associations. Bartlett's position is that we do not store verbatim memories. Our memories are *reconstructed* on the basis of what we already know. Both theories have had enormous impact on current views of memory, even though their perspectives are largely construed as antithetical.

The position I want to argue for here is that sometimes Bartlett's view is correct and sometimes Ebbinghaus' view is correct. Sometimes memory data seem best explained by Bartlettian principles and sometimes by those described by Ebbinghaus, because people can adopt one of several memory strategies. For example, people can try to retrieve information in a precise search of memory, looking for exact facts studied, or they can try to reconstruct what they have learned, in an imprecise way, making use of prior knowledge, as Bartlett has suggested. This chapter will illustrate that the same knowledge structure can produce dramatically different results, depending on the processes (or strategies) that are operating on that structure.

The notion that we have multiple strategies to retrieve information from memory has been neglected to a large extent. Only recently has the availability of multiple strategies been a topic of discussion. The contexts under which one strategy is preferred to another is an even less well explored area of research. Many theorists who discuss the availability of multiple strategies have assumed that the order of application is fixed or invariant. Below, the case will be made that not only are there multiple strategies for retrieving the same information, but that the order of selection of strategies is variable. Nonetheless, the factors that contribute to preference for one strategy over another can be understood.

The Role of Associations in Memory Retrieval

Numerous scholars have followed Ebbinghaus' tradition and have documented the importance of associations for understanding learning and memory phenomena. One domain within this broad category is that of interference. Much of forgetting and *difficulty in learning* can be thought of in terms of competing responses to the same stimulus association (see Crowder, 1976, for a review). The original Paired-Associate Learning paradigms demonstrating interference tended to measure performance as probability of recall to nonsense syllables; however, more recently, analogous results using response times have also been found for recognition of sentences (e.g., Anderson, 1974, 1976; Lewis & Anderson, 1976; Thorndyke & Bower, 1974). The Paired-Associate research showed that the probability of recalling a response to a cue declined if prior or subsequent associations were also learned to that cue or stimulus. The reaction time research showed that the more facts committed to memory about a particular concept, the slower a person is to *recognize* or reject (as not studied) any statement sharing that concept. This result was dubbed the "fan effect" by Anderson because of the assumed underlying propositional representation in which facts are stored as a set of links between concepts, and facts that share the same concepts all "fan out" from the concept node. This finding seemed quite robust. The monotonically increasing RT function with increasing fan obtained not only for facts about fantasy characters, it obtained for real facts about famous people (Lewis & Anderson, 1976; Peterson & Potts, 1982). That is, it takes a subject longer to verify that *George Washington chopped down a cherry tree* the more fantasy facts that were also studied about George Washington.

The theoretical explanation for the fan effect is as follows. Information is retrieved by spreading activation from concepts in working memory through the network of associated facts. The time required to retrieve information is a function of the level of activation that the concept nodes receive. Fanning of multiple paths from a concept node dissipates the activation the node sends down any one path and increases retrieval time.

The "fan effect" would never have been challenged if everyone subscribed to the Ebbinghaus tradition of using nonsense syllables or at least materials devoid of any inherent interest. Anderson's original materials were sensible statements, but they were random combinations (generated by a computer) of subjects, verbs and objects (screened for sensibility by a human). Smith, Adams and Schorr (1978) were intrigued by the paradoxical implications of the fan effect, that knowing more was detrimental. They replicated Anderson's findings, but only with statements that were thematically unrelated to one another. They had subjects in one condition study pairs of facts about fictitious individuals, such as:

Marty did not delay the trip.

Marty broke the bottle.

In another condition, subjects studied these two facts plus a third unrelated fact such as:

Marty painted the old barn.

Replicating past fan results, subjects were slower in the three-fan condition than in the two-fan condition. In another condition, however, subjects studied a fact that integrated the first two facts into a theme, such as:

Marty christened the ship.

When the third fact was thematically related to the other two, there was no difference in verification times between the two-fan condition and the three-fan condition.[1] Moeser (1979), too, found that thematicity changed the effects due to multiple associations.

The Smith et al. interpretation of their results seemed to follow the Bartlett tradition for the thematically related materials. They adopted the model proposed by Anderson for random pairings, but assumed an entirely different schema-like representation and process for the thematically related or more meaningful materials. Although Smith et al. partially resolved the "paradox of the expert" by showing that knowing more did not interfere when the material to learn was "integrated", several questions remained unanswered. Why would we have completely different knowledge representations and processes depending on whether the material is thematically integrated or not? On the other hand, why were people not *better* at making judgments when they knew more integrated material than when they knew less? Thematically related material only made the interference effects smaller. The next section will answer these questions.

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[1] In the Lewis and Anderson study, the fantasy facts about famous characters such as George Washington did not form a consistent theme, i.e., they were random combinations of other predicates.

DIFFERENT STRATEGIES FOR RESPONDING, NOT DIFFERENT REPRESENTATIONS

It is possible to explain the results found by Smith et al. without assuming different knowledge representations in the two conditions. Other work of my own (Reder, 1976; 1979) led me to believe that people may use inferential reasoning to answer a question even when the information is directly stored. The theory that people often prefer to make plausibility judgments over searching for a specific fact helps to explain the "paradox of the expert." The Smith et al. result that the fan effect attenuates with thematically related facts can be explained by assuming subjects often adopt a plausibility strategy to recognize the facts rather than actually search for a specific fact. That is, subjects decide that "It is *plausible* that I studied this fact if it is thematically consistent with other facts I know I studied." If finding any fact in memory about Marty consistent with ship-christening would suffice to "recognize" a specific Marty-ship-christening statement, then, of course, there would be little effect of the number of ship-christening facts associated with Marty. Thus, my analysis of the Smith et al. result is that subjects were using different strategies in the two conditions, not different knowledge representations.

This point of view is supported by the results of Reder and Anderson (1980). We replicated the results of Smith et al. using thematically related materials; however, we only replicated their results when the not-studied test foils were unrelated to the studied theme. A subject might study the following three facts:

The teacher went to the train station.

The teacher bought a ticket for the 10:00 train.

The teacher arrived on time at Grand Central Station.

In the block of trials where the studied statements were tested with unrelated foils, a foil to be rejected as unstudied might be:

The teacher called to have a phone installed.

An unrelated foil like this would allow the subject to use a plausibility judgment to make a "recognition" judgment. When the foils were thematically related to the studied theme, such as

The teacher checked the Amtrak schedule.

subjects could not use the plausibility strategy to make accurate recognition judgments. (In all conditions, the to-be-rejected foils were constructed by re-pairing studied predicate and occupation terms. In this way, foils could not be rejected because of unfamiliarity with lexical items.) When the foils precluded use of a plausibility strategy, the fan effect was as large with thematically related material as with unrelated material. Figure 1 shows the different RT functions for recognition judgments depending on the type of foil that was tested with the studied facts.

INSERT FIGURE 1 ABOUT HERE

Very different fan functions obtained with the same materials in different blocks of trials that differed only in terms of the type of not studied foils to reject. Since these different functions were produced by the same subjects, an explanation based on different long-term memory representations for thematically related materials is unlikely. Instead, it seems more reasonable to propose that interference or fan effects obtain in recognition tasks if the materials preclude the use of a plausibility strategy.

The question of why knowing more did not *facilitate* still remained. Other work (Reder, 1982) suggested a possible *explanation*: Strategy-selection is affected by a number of variables, in addition to the type of foils used. For example, the task demands (such as recognition vs. plausibility) or the strength of the relevant memory traces can affect which strategy is selected. In many situations there is a *mixture* of strategy use, such that sometimes one strategy is selected and sometimes the other is selected.[2] The relative mixture depends on variables such as those mentioned above. The flat fan function with thematically related materials might have resulted from a mixture of using the recognition (direct retrieval) strategy some of the time and the plausibility strategy the rest of the time. The fan function when plausibility is precluded shows a positive slope, so perhaps the fan function when plausibility is used exclusively would show a negative slope (yielding a roughly flat function when averaged together).

This speculation, that plausibility judgments would actually be facilitated by knowing more, was tested by Reder and Ross (1983). In this study, too, all subjects learned thematically related sets of information and were tested with those facts in a variety of conditions. As in Reder and Anderson, for some blocks of trials subjects were required to make recognition judgements in the presence of plausible (thematically related) foils, and for other blocks of trials they made recognition judgments in the presence of implausible (thematically inconsistent) foils. In addition, a new condition was used in which subjects were actually told to make plausibility or relatedness judgments rather than recognition judgments. They were to say "yes" to both the studied statements and the plausibly true, i.e., thematically related but unstudied statements. They were to say "no" to thematically unrelated statements. Figure 2 plots the fan functions for the three types of statements (studied, plausible, unrelated) used in the consistency block of

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[2]Some of the data supporting these claims will be described later.

trials.[3] Here, the fan function for the thematically related not-studied statements showed a sharp, *negative* slope. Those statements could only be accepted by a plausibility-like strategy. So the hypothesis that a plausibility strategy would show facilitation with fan was confirmed.

INSERT FIGURE 2 ABOUT HERE

It is worth noting that the slope for stated probes was also negative, but much less steep than for consistent, not-studied items. This too can be accounted for by assuming a *mixture* of the two strategies, since either one produces a correct response for studied statements. The bias to use plausibility was greater in the blocks where subjects were actually asked to judge thematic relatedness. To the extent that subjects were biased to use the plausibility strategy *more often as a first* strategy in the block requiring those judgments, the slope for the stated probes should be more negative than in the recognition block. Since only the plausibility strategy produces a correct response for the plausible, not-studied items, the function is much more steeply negative for them. Response times for these statements are also much slower than for the other test items because two strategies must often be tried before a correct response is given. That is, first the direct retrieval strategy is tried, but the statement is not found in memory. If the subject quits with a guess of "no", an error is recorded and the time is not averaged into the mean RT. If the subject elects to go on to make a plausibility judgement, the RTs are necessarily much longer than when only one strategy is used to make a decision. Note the high error rate for these statements as well.

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[3]The other blocks of trials replicated the earlier studies.

STRATEGY-SELECTION IS VARIABLE

The account given above implies that strategy-selection for question-answering does not proceed in a fixed order. Previous conceptualizations have assumed that people first attempt to answer a question by searching directly for the statement in memory. Only when it is clear that that fact can not be found is an inferential strategy evoked (e.g., Lachman & Lachman, 1980, Lehnert, 1977). There are a number of results that support the notion that direct-retrieval is not always the first strategy of choice. For example, data of Reder (1979) indicated that subjects make inferences even when the information is stored in memory. In those studies, subjects were asked to read short stories and make judgments about the plausibility of assertions on the basis of the stories that they read. Some of the statements to be judged had actually been presented in the story as part of the story (randomly determined for each subject). The plausibility of the test sentence with respect to the story affected judgment time even when the item had been explicitly presented. Although there was a clear RT advantage for stated (explicit) probes over not-stated probes, the plausibility of the statements affected presented probes as well. Figure 3 plots the data from the stated and not-stated conditions for the highly and moderately plausible probes when tested immediately after reading the relevant story.[4]

INSERT FIGURE 3 ABOUT HERE

One explanation for faster RTs for highly plausible statements assumes that the probability of drawing the inference and then finding it in memory is greater for the

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[4]The experiment also included "primed" inferences, and inferences that were verb-based, i.e., they immediately followed from the verb in an assertion. The statements were also tested at various delays. The subset of data graphed here seemed most representative and relevant.

highly plausible statements, and that subjects always try to search memory for a specific fact first. The problem with this explanation is that it predicts no plausibility effect for probes that had been stated in the story. A different explanation for both the plausibility effect and the speed advantage for stated probes is a race model where the direct retrieval strategy and the plausibility strategy execute in parallel. By assuming that sometimes one process wins and sometimes the other wins, both effects can be accounted for, the faster times for presented statements and for highly plausible statements.

The simple parallel race model described above can be ruled out if one considers the data of Reder (1982). Those experiments were quite similar to Reder (1979), except that some of the subjects were asked to make recognition judgments instead of plausibility judgments. Judgments were either made right after reading a story, after reading ten stories, or two days after reading all ten stories. In some conditions, subjects actually were faster at plausibility judgments at longer delays than at shorter delays. This is a result that a simple race model cannot explain. Subjects were faster at a delay in those situations where the direct retrieval strategy could not produce a correct response, namely for not-stated plausible inferences. Figure 4 presents the response times and error rates for the two tasks (plausibility and recognition) as a function of delay of test and whether the probes had been stated in the story.

INSERT FIGURE 4 ABOUT HERE

An explanation that can account for this result is to assume that at the shorter delay intervals, subjects are inclined to try the direct retrieval strategy first. That strategy will produce the correct response in many conditions. However, when subjects are asked to make plausibility judgments and fail to find the probe in memory, they must go on to try the plausibility strategy or risk making an error. At longer delay intervals, there is an increased tendency to try the plausibility strategy first. This means that for not-stated plausible inferences, the useless direct-retrieval strategy is avoided, making overall response times faster in that condition.

Other aspects of Reder (1982) also supported the notion that subjects became more inclined with delay to adopt the plausibility strategy first in both the plausibility task and the recognition task. Like Reder (1979), the plausibility of the test questions was also varied. The effect of plausibility, viz., the difference in response times between the highly and moderately plausible statements, increased at the longer delay intervals. Also, accuracy declined greatly for not-stated plausibles in the recognition task, especially for the highly plausible statements. Figure 4 shows that not-stated items in the recognition task were erroneously accepted 60% of the time. The error rates were 50% for the moderately plausible and 70% for the highly plausible.

Given the theoretical interpretation of Reder (1982), that subjects were more inclined to adopt the plausibility strategy as memory traces faded (i.e., at longer delays), it seemed reasonable to predict that at longer delays the pattern found by Reder and Ross (1983) in the fan paradigm would also show a stronger influence of the plausibility strategy, viz., more of a negative slope. Reder and Wible (1984) conducted an experiment similar to Reder and Ross, in which the major difference was that subjects were tested 48 hours after learning the material as well as being tested on the day of learning.

As expected, the effect of fan (the number of sentences sharing the same concepts) was strongest in those conditions where only one strategy could produce the correct response. Subjects asked to make recognition judgments showed the greatest interference from increased fan for the thematically related, not-studied items, replicating earlier results. Inconsistent items and stated items could be correctly recognized using the plausibility strategy as well as the direct retrieval strategy, so those RT functions were flatter. On the other hand, those subjects asked to make plausibility judgments showed the most facilitation from increased fan for the related, not-studied items, since only the plausibility strategy would work.

The prediction that subjects would be more inclined to use the plausibility strategy at longer delays was supported by a number of results in Reder and Wible (1984). Figure 5 shows the mean facilitation or speed-up from first session to second session as a function of task and probe type. For all items, subjects are somewhat faster during the second session, possibly due to practice or due to greater fatigue during the first RT session after learning the materials. It is reasonable to consider the flat line for the stated probes as a base-line of no true facilitation or loss due to strategy-shifts, since either strategy works equally well for these items. The most interesting changes in relative speed from the first to the second session are for the related, not-stated items. In the recognition task, where the plausibility strategy would produce the wrong response for these items, there is a relative hindrance due to the strategy shift, i.e., much less speed-up than the base-line. In the consistency task, where only the plausibility strategy produces the correct response, there is the greatest speed-up. Presumably this occurs because there are far fewer trials where subjects first use the inappropriate direct-retrieval strategy prior to the plausibility strategy.

INSERT FIGURE 5 ABOUT HERE

The speed-up results described above are inconsistent with a simple, parallel race model for the same reasons that the speed-up in Reder (1982) is inconsistent with it. Other aspects of the data also argue for a shift in strategy-preference (from direct-retrieval to plausibility) with delay. The slopes of the fan functions, negative for the consistency task and positive for the recognition task, both become more negative at the two-day delay. This is because with a greater portion of trials using the plausibility strategy at a delay, there should be more of a facilitation effect from increased fan.[5]

The accuracy data also showed a shift towards greater use of the plausibility strategy at longer delays. Figure 6 displays the accuracy data as a function of relevant fan, task, delay and type of test probe. During the first session, in which the subjects tended to use the direct retrieval strategy for the plausibility task, accuracy was poor for thematically related, not-stated probes, since it produced the wrong responses (no's instead of yes's). Accuracy improved 10% for both levels of relevant fan with delay for those statements where both strategies could not work.

The accuracy pattern in the recognition task showed the opposite trend for the related statements for exactly the same reason. These were the only probes that would produce an error when the plausibility strategy was invoked. At the delayed test, there was a greater tendency to use the plausibility strategy and so more errors were made. Furthermore, these probes were 10% worse in accuracy for the high-fan condition, i.e., when there was more information consistent with the theme of the not-studied probe.

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[5]In the recognition task, the slope changed from a +135 msec. slope to a -65 msec. slope at a delay; in the consistency task, the slope showed less influence of interference initially, starting with a +12 msec. slope and shifting to a greater facilitation than in the recognition task, -146 msec. slope. These slopes are only computed for the stated and inconsistent probes since only one strategy can be correctly used for the not-stated inconsistent probes.

INSERT FIGURE 6 ABOUT HERE

What are the Mechanisms for Strategy-Selection?

Several conclusions seem clear given the results described above. Questions are not always answered by using the same question-answering strategy or process. Which strategy is used to answer a given question is variable. The available strategies do not compete for execution by racing against each other to see which one will complete first. A non-fixed order serial model can easily account for the data described. A parallel race model can also account for the data described if we assume that the *allocation of processing resources* is unequally distributed for the two strategies. By assuming a shift in the allocation of resources from one strategy to another instead of a shift in which strategy is tried first, the same pattern of speed-ups, etc. can be explained.

Regardless of whether or not one assumes a variable, serial strategy-selection model or a differential allocation of resources in a parallel-race model, it still follows that there must be a preliminary process that determines strategy-selection or allocation of resources among strategies. This preliminary process has two sub-components or stages: An initial evaluation of knowledge relevant to the question followed by a more conscious decision of which strategy to follow. I propose that the initial evaluation is an automated process while the decision is a controlled process (e.g., Neely, 1977; Posner & Synder, 1975; Shiffrin & Schneider, (1977).

INITIAL EVALUATION

A number of factors are involved in the initial evaluation. One involves assessing how familiar are the words in the question. The more familiar the words, the more a person is biased to direct retrieval. Initial evaluation also involves assessing how many intersections in memory there are among the words from the question. The more intersections, the more the person is biased towards plausibility.

The idea that we can automatically determine the familiarity of the concepts provided in the question has been proposed elsewhere, e.g., Hasher and Zacks, (1979), Jacoby and Dallas, (1981), Mandler (1980). The activation-level of the terms in memory that were referred to in the probe can be compared with their "resting" activation levels. If they seem higher than expected at the time of questioning, it is assumed that the words were encountered recently.

The proposal that relatedness affects decision times is also not new (e.g., Rips, Shoben and Smith 1973). In my view, the "relatedness" of the concepts in the question is monitored through the interconnections in memory. Relatedness is defined as the degree to which words in a question cause *activation* to intersect in memory. The more intersections detected in memory as a result of a query, the more potentially relevant information is available for question-answering.

Familiarity-detection and intersection-detection are processes that monitor the automatic spread of activation from the concepts in the question. This spread of activation is assumed to be automatic, as are processes that monitor the level of activation and the extent of intersections. The bias to use the direct-retrieval strategy "trumps" the plausibility strategy since direct-retrieval is a faster and easier strategy than judging plausibility when the queried fact is relatively accessible. This is because when memory search is relatively easy, the plausibility strategy does not have the search-time advantage to counteract its long, plausibility computation time.

STRATEGY SELECTION

In deciding which strategy to apply, the subject integrates the biases from the initial evaluation along with considerations or factors that are *extrinsic* to the test question. These extrinsic factors include things like task instructions and probability that a particular strategy will be successful. Some of these variables have already been shown to influence strategy-selection, e.g., form of the instructions (Gould & Stephenson, 1967; Reder, 1982), ease of discrimination among alternatives (Lorch, 1981; Reder & Ross, 1983; Reder & Wible, 1984), impressions of one's own expertise (Gentner & Collins, 1981) and form of the question (Rips, 1975).

In addition to these variables, it seems reasonable that strategy-selection would be affected by recent prior history of success with a strategy, nominal constraints of the task, special knowledge that a strategy will or will not work, and motivation to perform well. The influence of extrinsic factors on strategy-selection is partly a function of how strong the bias is from the automatic assessment of "feeling of knowing" from the first stage and how compelling are the factors from this stage. If there is overwhelming evidence that a strategy will not work, or if subjects are heavily penalized for making errors, they may ignore the biassing information from the automatic assessment.

EVIDENCE FOR THE EXISTENCE OF A STRATEGY-SELECTION STAGE

I have conducted a number of experiments that are consistent with the idea that there is a preliminary mechanism that allows us to select a particular strategy for question-answering (Reder, note 1). Some of these experiments supported the proposal that people can assess their memories before actually doing a careful search of memory. People can estimate that they can answer a question such as "Who invented the telephone?" significantly faster than they can actually answer it. This faster estimation time is achieved without sacrificing accuracy. That is, those subjects who estimated that they could answer a question typically could answer the question, and they answered as many correctly as those in the answer condition. If accuracy is defined as the ratio of percent correctly answered to percent attempted, the estimate group was more accurate (Percent attempted is defined as one minus the probability of saying "can't answer").

Another experiment lent support to the mechanisms hypothesized to influence "feeling of knowing". This experiment primed some of the terms in some of the questions that subjects would later have to estimate or answer. It was expected that having rated the word-frequency of a couple of the terms in a question would give the person an illusory "feeling of knowing." One-third of the questions were primed in this manner. Subjects asked to estimate whether or not they thought they could answer a question over-estimated their ability to answer difficult questions that had been primed. For subjects who were asked only to give answers, the priming manipulation did not influence percentage of questions attempted. However, it did affect how long subjects took to decide that they could not answer a difficult question: Primed, difficult questions gave an illusory "feeling of knowing" which caused subjects to search much longer before realizing that they did not have the answer. Estimation *times*, on the other hand, were not affected by priming. If anything, estimation times were faster for those questions that were primed.

Other experiments in Reder (note 1) showed that strategy-selection was affected by variables extrinsic to the question. One study varied the proportion of the probes to be judged for plausibility that were actually presented as part of the story subjects read. When 80% of the test items had been presented as part of the story, subjects were expected to adopt the direct retrieval strategy; when only 20% were presented as part of the story, subjects were expected to adopt the plausibility strategy. Given that both groups were asked to make plausibility judgments, any difference in response time patterns would be due to sensitivity to the ratio of presented to not-presented statements. The results quite clearly indicated that subjects were sensitive to the ratio of presented to not-presented test probes. For those subjects that received predominantly presented probes, and were therefore biased to use the direct retrieval strategy, there was a large difference in verification RT between presented and not-presented statements, such that the not-presented were much slower. For those that received predominantly not-presented probes, and were therefore biased to use the plausibility strategy, there was essentially no difference in verification RT between the presented and not-presented probes. Conversely, there was a large plausibility effect (difference in RT between highly and moderately plausible statements) for subjects biased to use the plausibility strategy, and only a very small effect for subjects biased to use direct retrieval. For the latter group, all of the plausibility effect came from those statements that could not be verified using direct retrieval.

This manipulation of varying the proportion of presented to not-presented statements was done only for the first six of the ten stories in the experiment. Starting with the seventh story, the ratio of presented to not-presented reverted to the standard 50:50. For these last four stories, the results showed a return towards a moderate use of each strategy, i.e., the bias functions converged. This is also evidence that subjects could adjust their strategies fairly rapidly. It should be pointed out that the bias manipulation and the shift back to neutral was never explicitly mentioned to the subjects.

Another experiment was designed to see whether people can switch strategies at a moment's notice depending on the advice they receive prior to the question. Again all subjects were asked to make plausibility judgments; however, before each question, they were told whether they would be better off searching for a specific fact in memory of trying to actually compute the plausibility of the statement. They were also warned that although the advice would usually be appropriate, it would not always be. When the advice was wrong, they were to still try to answer the question correctly (i.e., to use the other strategy). The advice was correct 80% of the time.

The results clearly indicated that subjects find it quite easy to follow advice and switch strategies from trial to trial. There were clear differences in RT pattern depending on which strategy had been recommended. For example, there was a much bigger RT difference between the moderately and highly plausible presented statements if the advice had been to compute the plausibility of the answer than if the advice had been to search for the fact in memory. Further, when the advised strategy would not produce the correct response, response times were much slower, because subjects had to go on and adopt the second strategy as well. Subjects were especially slow for not-presented statements where the (wrong) advice had been to try direct retrieval.[6]

In summary, these experiments lend support to the theory of strategy-selection for question-answering. We can assess our feeling of knowing, which is sensitive to the recency of exposure to words and the extent of intersection in memory among the concepts referred to in the probe. Further, we integrate our initial evaluation with facts that we can more consciously assess in order to select one strategy to try first (or to which to devote most of our processing capacity).

General Conclusions

This volume is in honor of the hundredth anniversary of the publishing of Ebbinghaus' famous treatise on human memory. The message of this contribution is that we should reconsider Ebbinghaus' "laws" from the perspective that memory

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[6]It is worth noting that data such as these also argue against a simple parallel race model between the two competing strategies, confirming the view of a strategy-selection process.

performance reflects cognitive strategies and that these strategies vary from situation to situation. For example, the same structure of associations can either hurt memory performance or facilitate it depending on other constraints of the task. It is no wonder then that the conclusions of Ebbinghaus and those of Bartlett seem so contradictory. Each had constructed tasks and tested subjects in situations that encouraged completely different strategies. Ebbinghaus constructed tasks that required veridical, verbatim recall that minimized the usefulness of prior knowledge. Bartlett used tasks that encouraged reconstruction of the information by using prior word knowledge. Both sets of "laws" or principles are useful, so long as we acknowledge that they apply only in contexts that encourage the corresponding memory strategy.

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Figure Captions

Figure 1. Mean RT for correct recognition judgments, plotted as a function of the number of predicates associated with the probed character, and whether the block of trials used thematically related or unrelated foils. The data are averaged over yes and no responses. (Adapted from Reder & Anderson, 1980, Experiment 2, Figure 4.)

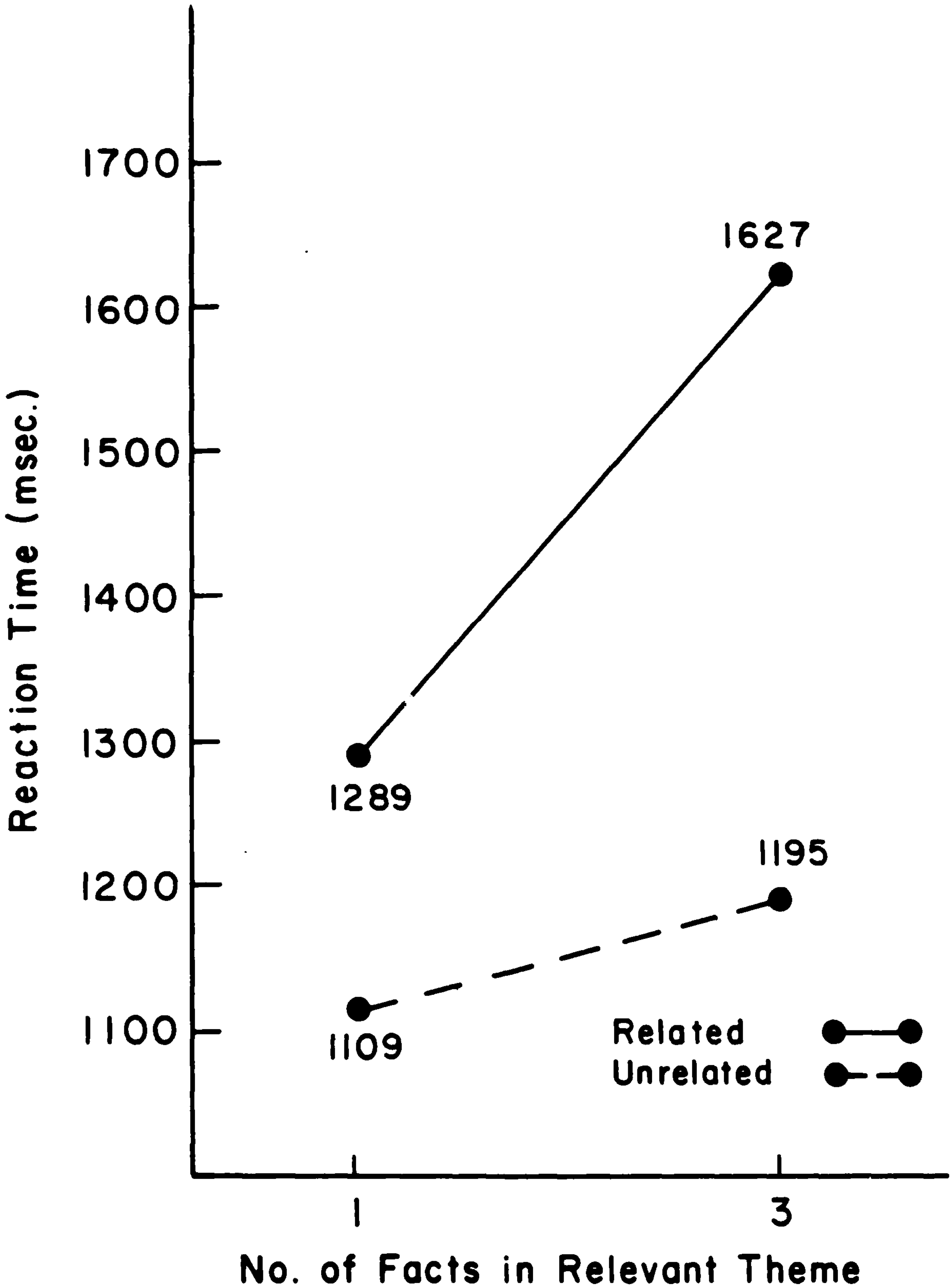
Figure 2. Mean RTs (and proportion of errors) as a function of relevant fan and type of probe in the consistency task. (Adapted from Reder & Ross, 1983, Figure 3a.)

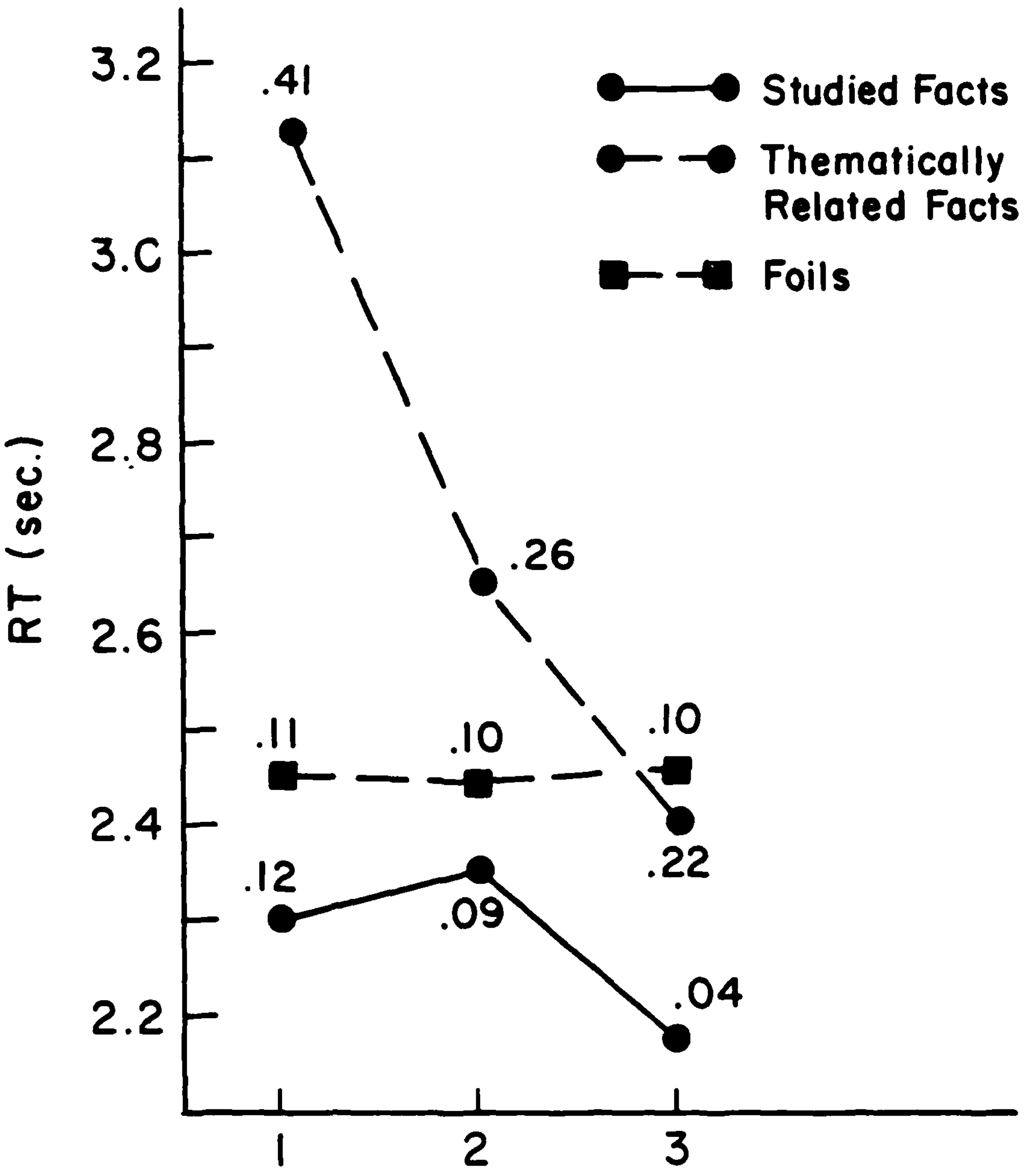
Figure 3. Mean RT for correct plausibility judgments (and error rates), plotted as a function of plausibility of the test probe and whether it had been presented in the story. (Adapted from Reder, 1979, Experiment 1, Figure 1.)

Figure 4. Mean RT for plausibility and recognition judgments as a function of whether the probe had been stated in the story, plotted across levels of delay. (Adapted from Reder, 1982, Experiment 1, Figure 3.)

Figure 5. Mean facilitation or speed-up from first session to second session, plotted as a function of task and probe type. (Adapted from Reder & Wible, 1984, Figure 2.)

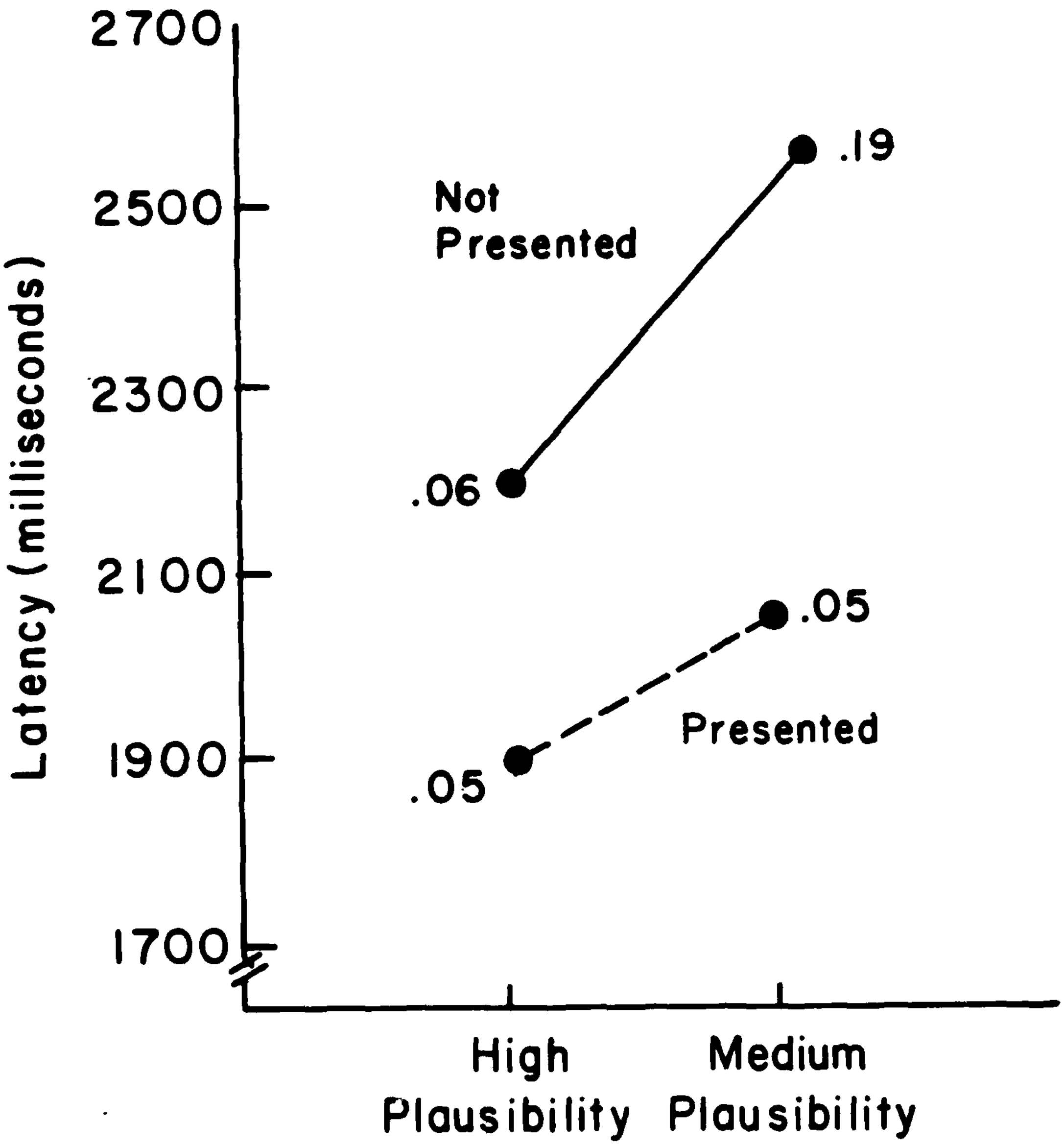
Figure 6. Mean percentage correct for judgments in the recognition task (top) and consistency task (bottom), plotted as a function of relevant fan for each probe type. The short-delay data are displayed in the left quadrants, and the long-delay test data are plotted on the right. (Adapted from Reder & Wible, 1984, Figure 3.)


Reaction Time (msec.)
1700
1600
1500
1400
1300
1200
1100
1627
1289
1195
1109
Related
Unrelated
1
3
No. of Facts in Relevant Theme
FIGURE 1



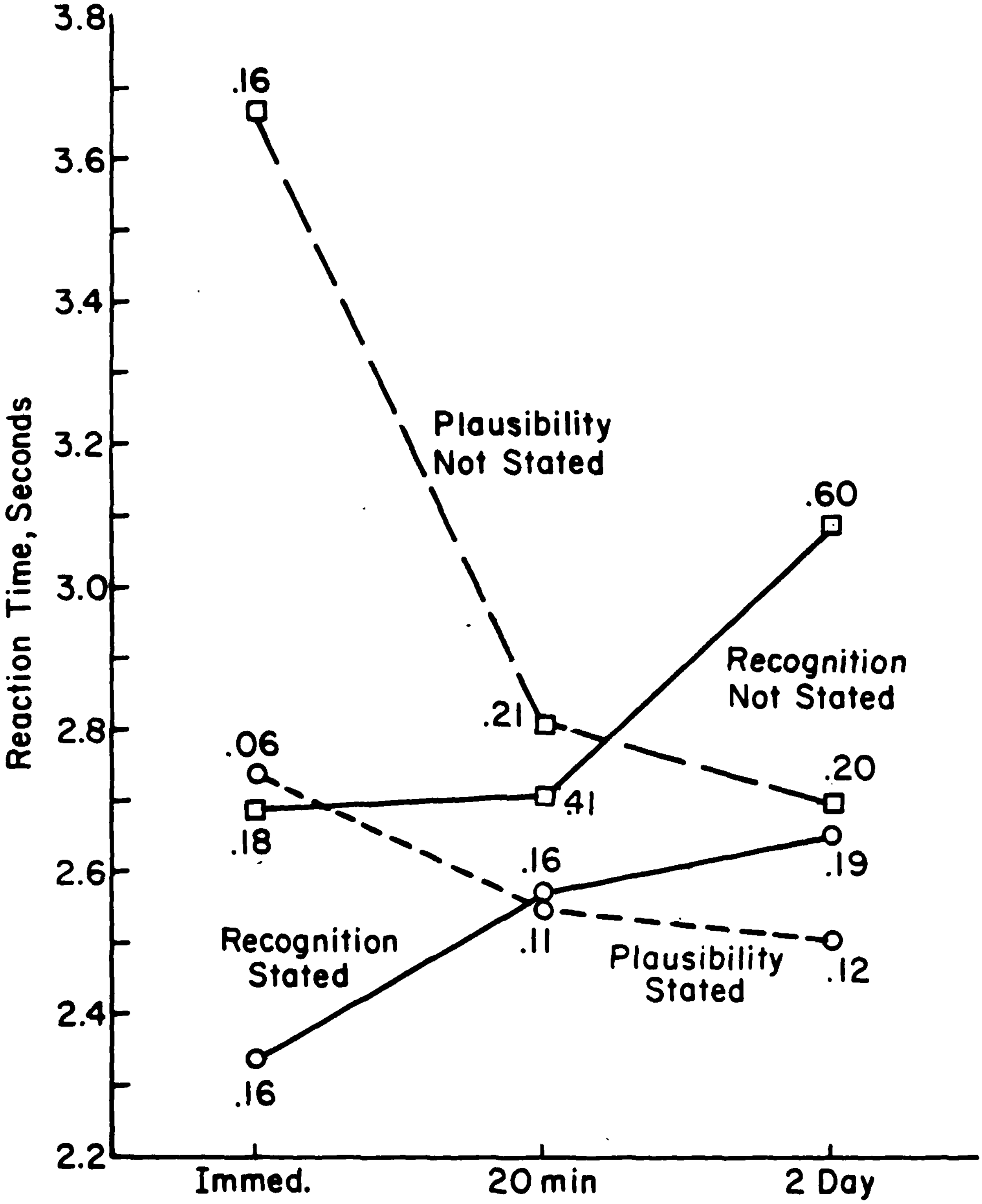
3.2
3.0
2.8
2.6
2.4
2.2
RT (sec.)
1
2
3
.41
.26
.22
.11
.10
.10
.12
.09
.04
Studied Facts
Thematically Related Facts
Foils

FIGURE 2



2700
2500
2300
2100
1900
1700
Latency (milliseconds)
Not Presented
.19
.06
.05
.05
Presented
High Plausibility
Medium Plausibility

FIGURE 3



3.8
3.6
3.4
3.2
3.0
2.8
2.6
2.4
2.2
Reaction Time, Seconds
.16
Plausibility
Not Stated
.60
Recognition
Not Stated
.21
.06
.41
.20
.18
.16
.19
Recognition
Stated
.11
Plausibility
Stated
.12
.16
Immed.
20 min
2 Day

FIGURE 4

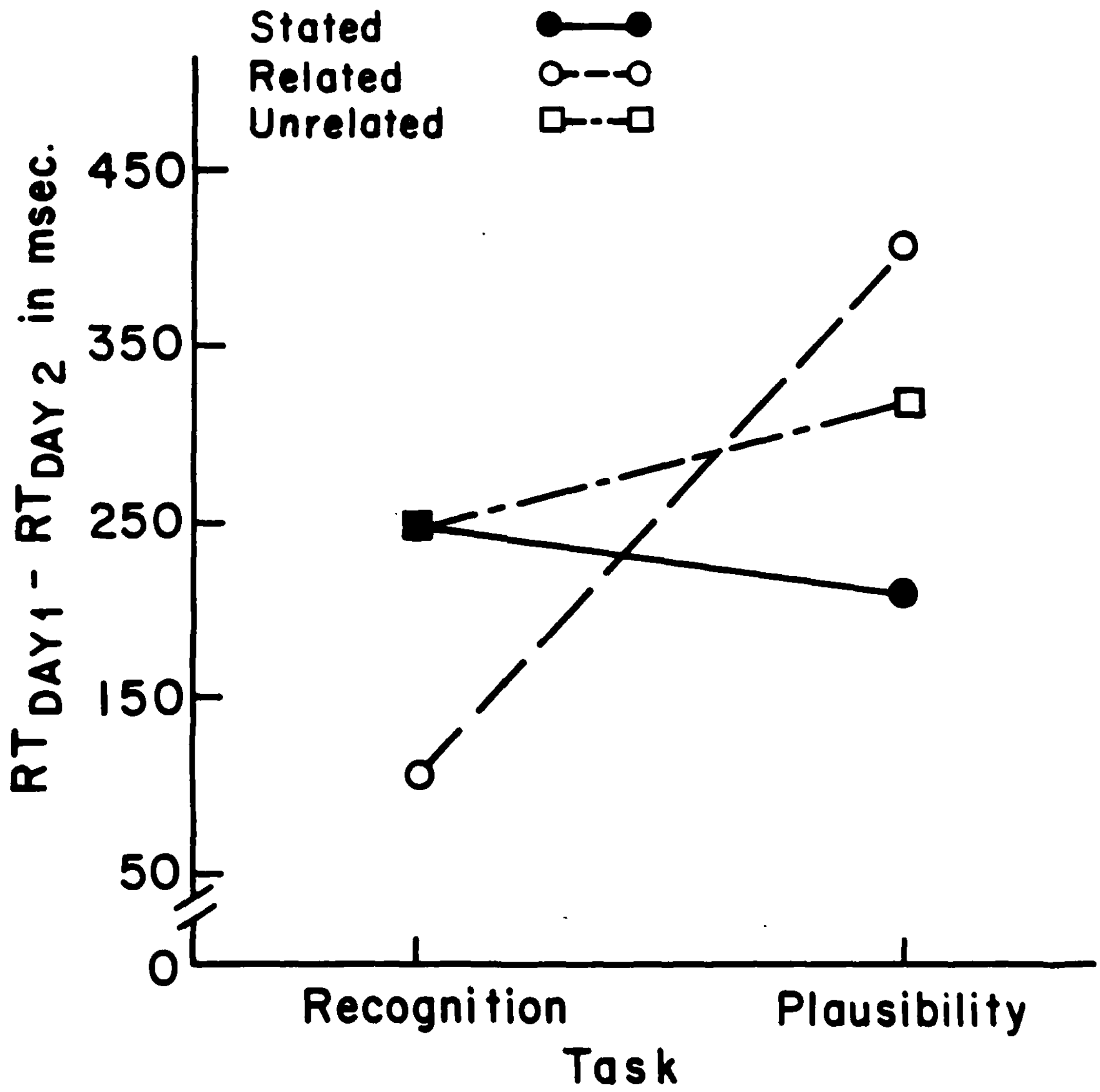
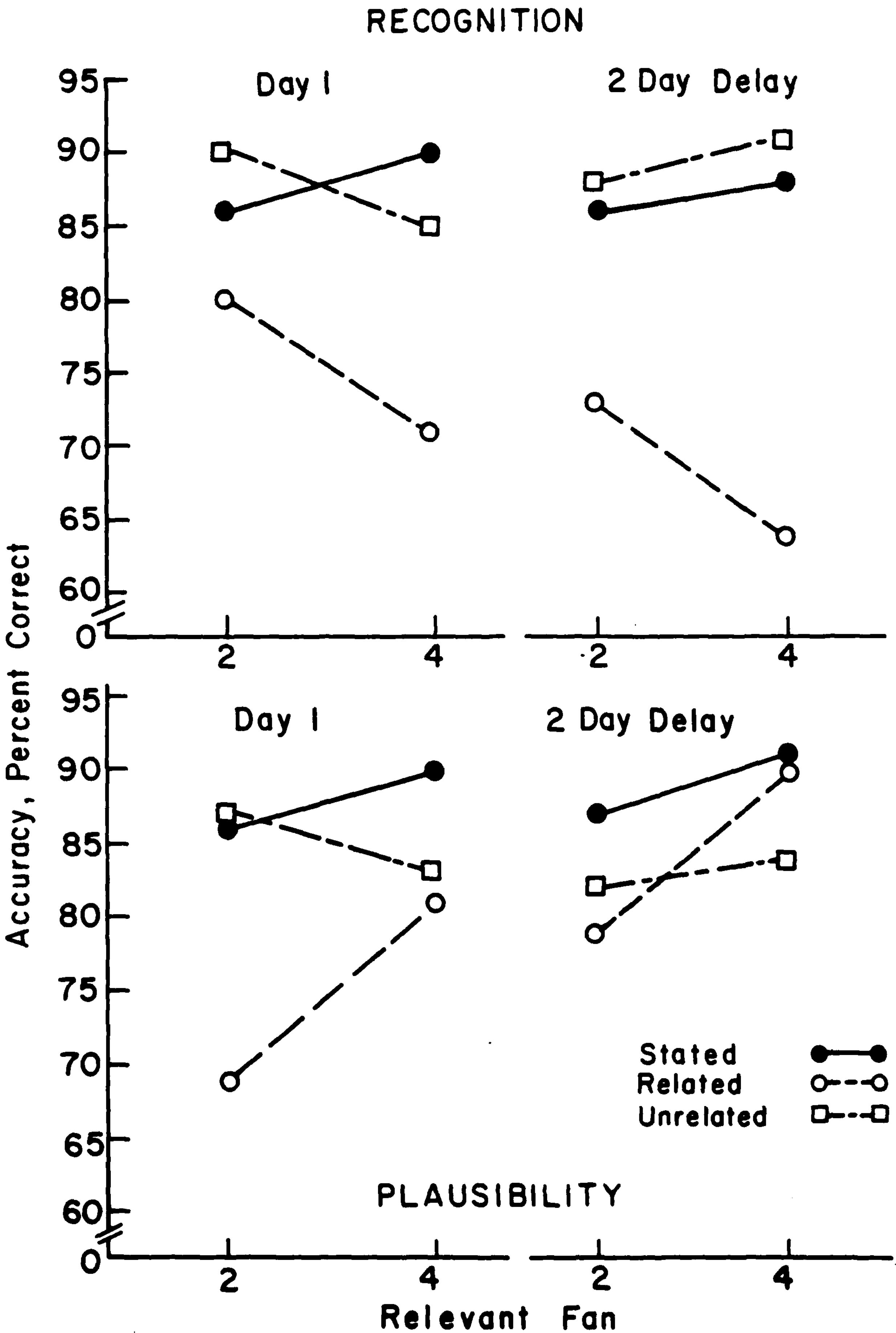

Stated
Related
Unrelated
450
350
250
150
50
0
RT DAY1 - RT DAY2 in msec.
Recognition
Plausibility
Task

FIGURE 5


RECOGNITION
Day 1
2 Day Delay
95
90
85
80
75
70
65
60
0
2
4
2
4
Accuracy, Percent Correct
Day 1
2 Day Delay
95
90
85
80
75
70
65
60
0
Stated
Related
Unrelated
PLAUSIBILITY
2
4
2
4
Relevant Fan
FIGURE 6

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