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The Inferential and Experiential Bases of Metamemory

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There is a long tradition of research by psychologists on the objective characteristics of humans as learners and rememberers. Only recently, however, have researchers also begun to explore the ways in which the subjective aspects of remembering play a role in the ongoing monitoring, regulation, and control of learning. How easily answers or procedures come to mind, for example, influences people's judgments of how well they "know" some information or skill; the sense of "familiarity" people have when they read or hear information, or watch someone perform a to-be-learned procedure, also influences their estimates of how much they know, and how much they have yet to learn. Whether a name a person cannot currently recall seems to be "on the tip of the

tongue" may also determine how vigorously the person searches for or how soon he or she abandons the search for that name. In all these cases, people's phenomenological, subjective assessments of their own mental state influence their behavior in important ways.

The research domain of metamemory involves the study of the knowledge people possess about memory in general, and about the state of their own memory in particular, as well as the subjective experiences that arise during learning and remembering—or failing to remember. Those experiences drive people's actions and influence their decisions, not just in the laboratory, but in the real world, as the following two scenarios illustrate.

- People often fail to remember the name of someone whom they quite clearly recognize. Perhaps, in walking across the street, you see an acquaintance, someone you went to school with or someone from your neighborhood. Just as you are about to greet him, you realize that you cannot recall his name, and must negotiate the ensuing conversation awkwardly without refer-

ring to him by name. If you feel that the name is on the tip of your tongue, you may prolong the conversation and attempt to recall the name while the acquaintance is present. Conversely, if you do not have the sense that recall of the name is imminent, you may direct your cognitive effort toward effecting a quick escape!

- Imagine a student studying for an exam. It is well past midnight; she has been studying for hours and is exhausted. The decision that this student must make is whether she has studied the material for the exam sufficiently and can go to sleep, or whether she must brew another pot of coffee and keep studying. In this case, too, metamemory is critical. The student must decide whether the material is generally well learned and, if not, what information must be studied further. These metamnemonic decisions influence not only the student's caffeine intake but also her studying behavior and, ultimately, her test performance (see Nelson, 1993).

The need to assess one's own competence is far broader than the second example just cited. In a variety of settings, how people allocate their time, whether they seek further instruction, whether they volunteer for certain jobs or assignments, and the influence they have on others are all dependent on how they evaluate their preparedness to

Recommended Reading

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perform—that is, on their assessment of whether they have the requisite skills and knowledge. In recent publications, in fact, we (Bjork, 1994, *in press*; Jacoby, Bjork, & Kelley, 1994) have argued that teaching people to interpret what their subjective experience tells them about their later performance is as important as teaching people how to do things more efficiently. In a variety of settings where on-the-job learning as a consequence of errors and mistakes poses an unacceptable risk, such as air-traffic control, police work, and nuclear-plant operation, it is crucial that individuals possess the skills and knowledge they think they possess. Our goal in this article is to demonstrate that evaluating one's current state of knowledge or skill is primarily an inferential process, and to characterize some of the progress that has been made in understanding how subjective experiences influence such evaluation and consequently the management and interpretation of one's own memories.

EVALUATING ONE'S OWN STATE OF KNOWLEDGE AND SKILL: TWO VIEWS

In this section, we contrast two theoretic viewpoints on how metamnemonic evaluations (*i.e.*, evaluations about how one's memory functions) are made. Those two major viewpoints embody two opposing, but not mutually exclusive, psychological bases for prediction and are termed the direct-access approach and the inferential approach (for more thorough reviews, see Nelson, Gerler, & Narens, 1984; Schwartz, 1994).

The Direct-Access Approach

According to the direct-access view, metamnemonic judgments

are based on sensitivity to the actual memory trace about which a judgment is being made. Such theories imply that people have explicit access to the strength of various memory traces (even those that cannot be recalled) and that people can use this access to inform judgments concerning their current or future states of knowledge. For example, such theories posit that when a word or name that you are trying to remember but cannot induces a tip-of-the-tongue experience, the cause of the experience stems from actual activation of the particular word being sought.

The direct-access view has two important implications. First, because metamnemonic judgments are presumed to be based on the strength of a memory trace, variables that act to increase memory strength should also have a corresponding influence on such judgments. Manipulations that improve memory performance, for example, should increase judgments of that performance as well (*e.g.*, Dunlosky & Nelson, 1994). Second, the relative accuracy of predictions of later performance should never be systematically inaccurate because such predictions are assumed to be based on the target information in memory. In other words, there should not exist circumstances in which more weakly stored information, as measured by actual later performance, is predicted to be more recallable than more strongly stored information.

The Inferential Approach

According to the inferential view, in contrast, people do not have direct access to the strength of memory traces. Rather, metamnemonic judgments are based on a host of other sources of information to which people do have access. Such sources may include related information that is retrieved

in response to a cue, the fluency with which an item has been recalled, or the familiarity of a cue to which the to-be-retrieved information is associated. People make inferences concerning the memorability of a target item based on such currently accessible information. In some cases, an inference may be largely nonconscious and reveal itself as a "feeling," or subjective experience. In other cases, a person uses a theory of what makes information memorable to translate subjective indices—such as the ease with which information can currently be recalled—into predictions of future performance. For example, a student currently able to recall the capital of California with ease but only barely able to recall the state flower might assume that this difference in ease of retrieval reflects important differences in the underlying state of learning, and allocate additional study time correspondingly. Whereas such a heuristic might provide for appropriate allocation of study time, the nature of the impending test will affect the utility of this strategy. Thus, according to the inferential view of metamemory, the complexity and accuracy of a person's mental model of memory play a crucial role in determining the person's accuracy in predicting his or her performance on a particular test.

The inferential view leads to different predictions than does the direct-access view. First, the inferential view suggests that variables may affect memory and metamemory differentially (see Metcalfe, 1993; Reder & Ritter, 1992), because metamnemonic judgments are not based directly on memory traces. Second, because inferences may be systematically erroneous in some cases, the inferential view, unlike the direct-access view, predicts that there may be situations in which judgments of memorability and actual later performance are correlated negatively. In these

cases, the theories of memorability that people employ would be leading them to utilize cues that are diagnostic of future performance, but in a completely backward manner. An example of just such a situation is presented in a later section.

EVIDENCE FAVORING THE INFERENTIAL VIEW

In this section, we discuss findings that bear on the contrasting views just outlined. Our goal is not to provide a review of the literature, but rather to indicate the types of findings that have provided steadily increasing support for the view that memory representations are not directly accessible, and their existence and strength must be inferred.

Problems With the Direct-Access View

The dissertation work of Hart (1965), often credited for marking the beginning of the empirical study of metamemory, seemed to support the direct-access view. In his experiments, he demonstrated that people could accurately predict their ability to recognize the correct answers to general-information questions for which they could not currently recall the answers. *Feeling of knowing* was interpreted as a sensitive measure of presence or absence of knowledge—a measure that, like recognition, was more sensitive than recall.

Later research, however, made such an interpretation unlikely. Using a task similar to that employed by Blake (1973), Koriatic (1993) showed that feeling of knowing for an unrecalled three-letter nonsense string correlated with the probability of accurate recognition of that string, but further demonstrated

that feeling of knowing varied with the number of letters, correct or incorrect, that could be recalled. An interpretation of feeling of knowing more consistent with this finding is that participants base their estimates of future recognition performance on how much information comes to mind, regardless of its accuracy, when trying to recall the answer (see Koriatic, 1995).

Other findings pose serious difficulties for the direct-access view of metamemory. In some cases, variables that enhance memory performance do not affect judgments correspondingly (e.g., Metcalfe, Schwartz, & Joaquim, 1993; Schwartz & Metcalfe, 1992). Moreover, there are situations in which metamnemonic judgments do not predict relative performance across items or conditions accurately (e.g., Koriatic, 1995), and even cases in which predictions rise as performance drops and vice versa (e.g., Begg, Duft, Lalonde, Melnick, & Sanvito, 1989; Benjamin, Bjork, & Schwartz, in press).

Recent Illustrations of the Inferential Nature of Metamnemonic Judgments

In what follows, we provide two detailed examples of recent experiments that strongly support an inferential basis for metamemory.

Tip-of-the-Tongue States

Many researchers interested in the tip-of-the-tongue (TOT) experience have tacitly assumed that the TOT state arises because of direct access to a strong, but currently un-retrievable, memory representation. This assumption is common for two reasons: First, in a TOT state, one subjectively "feels" that one is about to retrieve the answer, and may even have access to partial information about the target (A.S. Brown, 1991; R. Brown & McNeill, 1996); second, TOT states are

associated with high recognition accuracy and with high rates of eventual retrieval (Burke, MacKay, Worthley, & Wade, 1991).

Recently, however, we (Schwartz & Smith, 1997) have questioned the extent to which TOT states reflect direct access to memory representations. Rather, such states may reflect inferential processes. We based our hypothesis on recent theoretical work of Koriatic (1993, 1995), who argued that feelings of knowing are inferences based on the amount or intensity of partial information or related information retrieved about a sought-for but unrecalled target. That is, people base their judgments not on direct access to the target's strength, which they cannot retrieve, but rather on related knowledge or on partial information that they can retrieve, such as semantically related information. TOT states and feelings of knowing are strongly correlated, and therefore we chose to apply Koriatic's theory to TOT states.

To test this hypothesis, we (Schwartz & Smith, 1997) presented participants with lists of 12 nonsense words that were to be recalled later. Each word was paired with the name of a country, and 8 of the 12 were also accompanied by line drawings of fictional animals, as illustrated in Figure 1 (also see Smith, 1994). Participants were told that each nonsense word was the name of an animal, and the country name was the habitat of that animal. For example, the pair "Panama-yelkey" indicated that the "yelkey" is an animal that lives in Panama. Information pertaining to size and diet was presented for half of the eight animals for which line drawings were provided.

Thus, there were three presentation conditions: the name-country pair alone (the minimum-information condition), the name-country pair with a line drawing (medium-information condition),

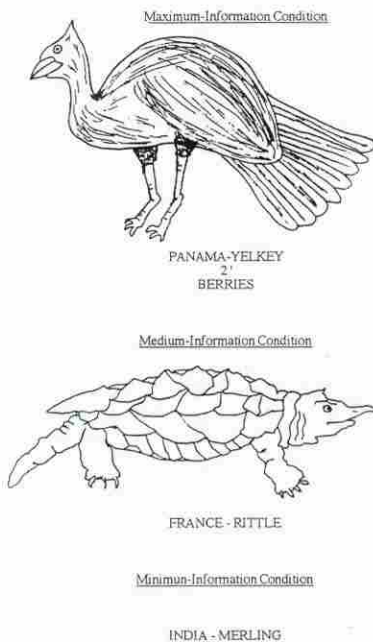


Fig. 1. Examples of stimuli used to study the relation between accessibility of information related to a to-be-recalled word and feeling that the word is on the "tip of the tongue" (Schwartz & Smith, 1997).

and the name-country pair with a line drawing plus diet and size information (maximum-information condition). The conditions were designed to allow different amounts of information to be retrieved when, at the time of test, the participants were given the country names as cues for the retrieval of the animal names. If the participants could not retrieve the name of the animal associated to a given country cue, they were then asked to indicate whether or not they were experiencing a TOT and to guess at the first letter of the animal's name. The participants were also asked to retrieve as much related information as they could. Related information included diet, size, and descriptions of the appearance of the animal.

As shown in Table 1, recall of animal names was uniform across the conditions. However, consistent with Koriat's theory, the number of TOT states did vary as a function of condition. More TOT

states were reported in the medium- and maximum-information conditions than in the minimum-information condition. Moreover, the probability of a TOT state correlated with the amount of related information recalled. The most succinct explanation is based on Koriat's theory: Participants reporting a TOT state retrieved some information concerning the animal and then inferred that because they could recall something about the animal, they would be able to recall the animal's name. This inference drove the TOT state. Although people may feel as though an unrecalled target itself causes the TOT state, in this case, the TOT experience occurred because of the accessibility of the related information.

Retrieval Fluency and Metamnemonic Judgments

The most convincing argument for the inferential approach to metamemory comes from studies that address the issue of metamnemonic accuracy. If metamnemonic judgments are inferences, researchers should be able to demonstrate the reliance of such judgments on particular indices other than the strength of the target memories. Such indices will often be correlated with memory strength, rendering them useful to the rememberer in predicting future retrievability. In some experimental situations, however, such indices may not be diagnostic of

later performance. To the extent that systematic mispredictions of performance are demonstrable, direct-access theories become less tenable. In particular, evidence of variables that affect retrieval in one way, but metamemory in another, supports the inferential view.

In some recent work, we (Benjamin et al., in press) focused on the inappropriate use of one index that might be used in making metamnemonic judgments: the ease or speed with which a memory trace is accessed. Such retrieval fluency is not always a reliable index of later recallability. In fact, there are circumstances in which initial ease of recall is associated with poorer later recall. We set out to assess whether people know how to modulate the use of this heuristic in the face of tasks in which it is misleading.

The basis for this experiment was an experimental procedure originally employed by Gardiner, Craik, and Bleasdale (1973). They asked participants to answer general-knowledge questions and later to recall the answers. Answers that had been retrieved with difficulty (i.e., more slowly) during the initial task were actually recalled later with a higher probability than answers that had been retrieved more rapidly during the initial task. This result, although counterintuitive, is explainable in terms of Tulving's (1983) distinction between episodic and semantic memory. Episodic

Table 1. Measures of recall and metamemory as a function of presentation of related information (Schwartz & Smith, 1997, Experiment 3)

Measure ^a	Condition		
	Minimum information	Medium information	Maximum information
TOT	11	19	19
Recall	34	33	33

^aThe TOT ("tip of the tongue") measure is the percentage of unrecalled answers for which participants reported a TOT experience. The measure of recall is the percentage of answers recalled correctly.

memory refers to memories for individual events, such as one's last birthday party or encountering a particular word in an experiment, whereas semantic memory refers to general world knowledge, such as the capital of France or your mother's maiden name. The initial question-answering task relied on retrieval from semantic memory. Difficulty of retrieval in the semantic task established a stronger episodic trace for the retrieval event. During later attempts to recall prior answers, therefore, the answers initially produced with difficulty were the most accessible. We suspected, however, that participants would judge that initially easy items would also be more memorable at a later time, and would mispredict their performance.

To test this hypothesis, we adapted the procedure Gardiner et al. had used. Participants were asked 20 general-information questions, such as "What is the only liquid metal at room temperature?" In response to each question, the participants were asked not only to answer the question but also to indicate the likelihood (on a scale from 1 to 100) that they would remember the answer ("mercury") on a free recall test to be given later. They were then distracted with an unrelated task for 10 min before being asked to recall their answers. Our results were consistent with the results of Gardiner et al. (1973) in that answers that were produced more fluently during the initial task were more difficult to recall later (Fig. 2, top panel). However, participants predicted that the initially easy items would be more likely to be recalled later (Fig. 2, bottom panel).

The fact that participants were systematically inaccurate in predicting their later performance is consistent with the inferential view of metamemory that we have sketched. Moreover, the correlation

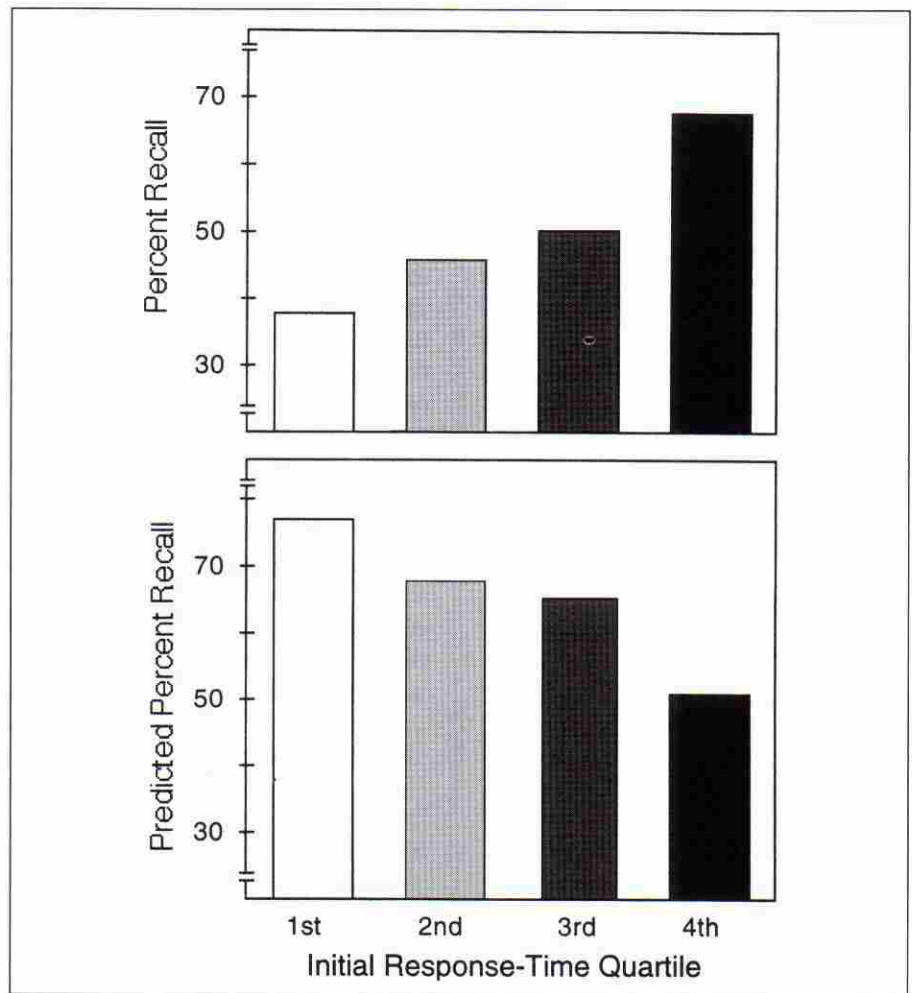


Fig. 2. Results from a study investigating how the ease with which a question is answered is related to the probability with which the answer is recalled later (top panel) and rememberers' predictions whether they will recall the answer later (bottom panel). Recall and predicted recall are graphed separately for participants categorized according to the speed with which they answered the question initially (e.g., the first quartile includes the 25% of participants who answered most quickly). Adapted from Benjamin, Bjork, and Schwartz (in press).

between prediction and performance was, indeed, negative. Participants gave higher judgments to those items they would later have a lower chance of remembering. Thus, it seems that they inferred their ability to recall a target based on the ease with which it was initially retrieved.

SUMMARY AND CONCLUSIONS

The research reviewed here supports the inferential view of

metamemory. In our first example, the frequency of TOT states was influenced not by the memorability of the target name, but by the accessibility of related information. Analogously, if you feel that a passerby's name is on the "tip of your tongue," it is not because you know the person's name, although it is likely that you do, but because the person's face is familiar. In our second example, higher judgments of recallability were given to items that were in fact harder to retrieve later. This result also illustrates the inferential nature of judgments:

People based their predictions of their own future recall on the rapidity of their responses to the original questions. Similarly, a student may base her evaluation of her preparedness for an exam on whether the material is easily retrievable now or seems familiar when read—assessments that may prove imperfect as predictors of access to that material on the exam itself.

What do these results imply about the nature of metamemory? First, metamnemonic experience is best thought of as an inferential exercise; people infer the objective nature of their memory and their future performance based on a variety of subjective cues, such as response speed. Whereas these cues may be diagnostic under certain circumstances, their heuristic nature makes them fallible under other circumstances. Second, because a variety of decisions, such as when to terminate study on a particular topic, are based on metamemory, understanding when subjective experience is diagnostic is important to the person who wishes to improve his or her ability to learn and remember.

In terms of the mysteries of human consciousness, what does the work sketched here, which is part of a broad body of behavioral and neuropsychological work on metacognition (see, e.g., Metcalfe & Shimamura, 1994; Nelson, 1996), have to say? In truth, nothing very concrete, but with respect to consciousness viewed as the “most fascinating invention of evolution” (Tulving, 1994, p. x), it is tempting to speculate that consciousness may have evolved out of a need to monitor one’s own cognitive processes. Subjective experience, in turn, may be a kind of internal “behavioral” reflection of processes that are otherwise inaccessible.

Whether this speculation is useful or not, one thing is clear: Subjective experience is as important in influencing people’s decisions and future performance as is objective performance. To quote Larry Jacoby (personal communication, September 1993), “Subjective experience, like the popular press, is unavoidable, serves useful functions, but is not to be fully trusted.”

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Note

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