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3

Rapid Feeling-of-Knowing: A Strategy Selection Mechanism

Adisack Nhouyvanisvong and Lynne M. Reder

The topic of feeling-of-knowing has received increasing attention (e.g. Hart, 1965; Koriat, 1993, 1994, 1995; Metcalfe, 1994; Metcalfe, Schwartz, & Joaquim, 1993; Miner & Reder, 1994; Nelson, Gerler, & Narens, 1984; Nelson & Narens, 1990; Reder, 1987, 1988; Reder & Ritter, 1992; Schwartz, 1994; Schwartz & Metcalfe, 1992). This growth in interest has focused on the accuracy of this feeling-of-knowing judgment and the variables that influence it. There has been much less concern with the purpose or functionality of the process. Most research that looks at feeling-of-knowing uses a paradigm that asks for a judgment following a memory retrieval failure.

This approach is reminiscent of the tip-of-the-tongue phenomenon (Brown & McNeill, 1966; Smith, 1994), although there are important differences. In the tip-of-the-tongue experience, a person who cannot retrieve the answer to a question is nonetheless confident that at some later point, the answer will come to mind. The person in a the tip-of-the-tongue state wants very much to retrieve the almost-available answer. In contrast, the subject in a feeling-of-knowing experiment is merely asked to rate the likelihood of being able to recognize the answer at some later time. Although subjects' judgments are far better than chance when judging feeling-of-knowing, they are typically not in a state of "I must keep searching! I know, I know this answer." Why then are subjects able to estimate the probability of recognizing the answer? It does not exist merely to keep memory theorists employed, and surely it does not exist solely for the tip-of-the-tongue experiences. What is the function of this process?

Feeling-of-knowing as part of a rapid strategy selection mechanism

Reder (1987, 1988; Miner & Reder, 1994) recently speculated that feeling-of-knowing is part of a more general process that occurs automatically when a question is asked. The purpose of this process is to help regulate strategy selection, and this operates for all questions, not just those for which answers are currently inaccessible. This view evolved from earlier findings that implicated a *rapid* initial process that directs allocation of resources to search memory or to calculate an answer or to otherwise respond "I don't know" (e.g. Reder, 1982).

Reder's (1982) subjects answered questions based on short stories they had read. One group of subjects was asked to decide whether a particular sentence was in a story (direct retrieval), while the other group was asked to judge whether a particular sentence was plausible given the story they had just read (plausible reasoning). Using the direct retrieval strategy meant searching memory for a close match to the queried target, whereas plausible reasoning meant constructing a plausible answer to a question, given a set of facts stored in memory. Half of the plausible test probes had been presented in the story. It might be reasonable to assume that subjects in the recognition group would exclusively use the verbatim or direct retrieval strategy whereas the plausibility group would use only a plausibility strategy. The data, however, indicated that subjects often first tried the strategy that corresponded to the other task. Specifically, at short delays between reading the story and test, subjects in both groups tended to use the direct retrieval strategy, while at a longer delay, both groups exhibited a preference for the plausibility strategy.

Latency and accuracy differences were used to infer strategy use. The test probes used in both the recognition and plausibility tasks were previously classified as highly plausible or moderately plausible (by other ratings). It is reasonable to assume that subjects should take more time to judge a moderately plausible test probe as plausible than a highly plausible test probe. In addition, subjects should be more likely to judge a highly plausible test probe as plausible than a moderately plausible one. However, when subjects are asked to make a recognition judgment, the time to decide whether a statement was presented should not vary with plausibility unless they are using the plausibility strategy when making recognition judgments. These plausibility effects did occur when subjects were asked to recognize whether or not the test probe was stated in the story. That is, subjects recognized moderately plausible statements more slowly than highly plausible ones, and also they recognized moderately plausible statements less often than highly plausible ones. Thus, latency and accuracy differences due to the plausibility of the test probes provide evidence for the use of the plausibility strategy in both the plausibility and the recognition tasks.

As stated earlier, subjects tended to shift away from using the direct retrieval strategy with an increase in delay between study and test. This shift in strategy is evidenced by the change in the size of the plausibility effects with delay. Differences in reaction time between moderately and highly plausible statements increased with delay for recognition judgments and stated (in the story) plausibility judgments. This suggests that subjects changed strategy preference from the direct retrieval at short delays to the plausibility strategy at longer delays. Additionally, this change in strategy preference for the plausibility strategy at longer delays is revealed by the error rates in the recognition task for not-stated items. Highly plausible test probes that were not presented in the story were more likely to be judged as previously presented, presumably because they were using plausibility as a heuristic.

If strategy preference changes with delay between study and test, then there must be some point at which subjects decide to use a given strategy. Other research (e.g. Reder 1987, 1988) provided additional empirical support for a rapid, pre-retrieval stage during which individuals judge the expected retrievability of a queried piece of information in order to select a preferred strategy. In these series of experiments, Reder again had subjects select between two strategies, direct retrieval and plausible reasoning. Subjects in these experiments also showed a tendency to switch from a direct retrieval strategy to a plausibility strategy as the delay between study and test lengthened, even when they could not anticipate the test delay before getting the question. In addition to delay, subjects were found to be sensitive to the probability of the success of each strategy, altering their strategy preference in accordance with the probability that a given strategy would prove effective.

The above pattern of results suggests that there must be a mechanism which rapidly regulates strategy selection. One component of this appears to be a rapid feeling-of-knowing that is based on the familiarity with the question terms rather than on partial retrieval of the answer (Reder, 1987, 1988; Reder and Ritter, 1992; Schunn, Reder, Nhouyvanisvong, Richards, & Stroffolino, 1997). We review the evidence for this conclusion below. Note that the position that feeling-of-knowing is based on cue familiarity is necessary for this view of its functionality: If feeling-of-knowing were based on a partial retrieval of the target, the decision to use the retrieval strategy would have already been initiated prior to the feeling-of-knowing process. Since we believe that a *rapid* feeling-of-knowing functions to guide strategy choice, it cannot be influenced by retrieval products. This is because retrieval is a strategy, whereas feeling-of-knowing is a strategy choice mechanism.

Two paradigms and views of feeling-of-knowing

The aim of this chapter is to clarify the difference in perspective among the various researchers working on the topic of feeling-of-knowing, and especially to clarify the differences in methodologies and the implications for differences in results. Briefly, the standard methodology has been to assess feeling-of-knowing *following* a memory retrieval failure. Reder (1987, 1988; Reder & Ritter, 1992; Schunn, et al., 1997), on the other hand, has assessed feeling-of-knowing prior to any retrieval attempt. The claim of this chapter is that feeling-of-knowing is used primarily to guide strategy use, and to regulate the length of search before unsuccessful termination once retrieval has been initiated. The standard feeling-of-knowing paradigm has explored a phenomenon that is much less prevalent in the real world. That is, people routinely decide how to answer a question and how long to search. With the exception of the tip-of-the-tongue state, people do not typically gauge their likelihood of recognizing an answer later.

Below, we explore the differences between the two types of paradigms, namely the *rapid* feeling-of-knowing vs. the post-retrieval failure paradigm. We review the differences in findings from these two paradigms and try to make clear the greater functionality of rapid feeling-of-knowing. More importantly, we want to distinguish the two paradigms and to reconcile their theoretical differences and seemingly contradictory findings.

Early work on feeling-of-knowing

In his dissertation, Hart (1965) explored whether the tip-of-the-tongue phenomenon generalized to other failed recall experiences. Hart was struck by the strong sense of knowing the answers that people had in tip-of-the-tongue experiences, and wondered whether in other situations people might also have an inkling of whether they really knew the answer. In this seminal work, Hart used a three-phase paradigm to assess feeling-of-knowing. First, the subjects were given a recall test. Second, for those items that were not correctly recalled, subjects were asked to give a feeling-of-knowing rating. Third, a recognition test was administered to determine the accuracy of subjects' feeling-of-knowing judgments.

Interestingly, Hart found that subjects were significantly above chance in predicting correct recognition and recognition failure for those items which they were not able to recall. When subjects gave a low feeling-of-knowing rating, indicating that they did not know the answer, their performance on the recognition test was at chance level. However, when subjects gave a high feeling-of-knowing rating, suggesting that they knew the answer, their performance on the recognition test was three times the level of chance.

Since Hart's seminal work, other researchers have extended these findings. Nelson and his colleagues have shown a negative correlation between feeling-of-knowing and perceptual identification latencies for tachistoscopically presented answers to previously unrecalled general knowledge questions. That is, as feeling-of-knowing judgments increased, identification latencies decreased (Nelson et al., 1984). This result suggests that the metacognitive system is more sensitive to perceptual information than to a high-threshold task such as recall. However, this conclusion was qualified by a later study. Jameson, Narens, Goldfarb, and Nelson (1990) found that feeling-of-knowing ratings were not influenced by the perceptual input from a near-threshold prime. However, if the information had been recently learned, that same perceptual input increased recall for previous recall failures. This finding is consistent with earlier results of Nelson, Leonesio, Shimamura, Landwehr, & Narens (1982), who reported that feeling-of-knowing judgments were not accurate for word pairs learned to a criterion of one successful recall, while accuracy for overlearned word pairs increased significantly beyond chance. One can conclude from this line of research that the accuracy of feeling-of-knowing judgments is well above chance yet "far from perfect" (Leonesio & Nelson, 1990).

In addition to prediction of accuracy, feeling-of-knowing has been shown to be correlated with search duration. Nelson et al. (1984) presented subjects with general information questions, then asked them to make feeling-of-knowing judgments for the first 21 questions that they could not recall. The researchers used a perceptual-identification task and a multiple-choice recognition test as the two measures of knowledge for the unrecalled item. They found that latencies to commit an error of commission (give the incorrect answer) were not correlated with either recognition or perceptual identification. However, the latency to say "don't know" was significantly correlated with the feeling-of-knowing. That is, when subjects experienced stronger feelings of knowing, they searched longer.

Several researchers exploring the feeling-of-knowing phenomenon have speculated about the underlying mechanisms that are involved in this process. One viewpoint that has received some attention is the *trace access* hypothesis. This presumes that subjects have partial access to, and are able to monitor some aspects of, the target item during feeling-of-knowing judgments (Nelson et al., 1984). The evidence for this hypothesis comes from studies that have shown that, even when subjects cannot recall a target item such as a word, they can still identify information such as the beginning letter or the number of syllables it contains (e.g. Blake, 1973; Koriat & Lieblich, 1977).

An alternative viewpoint to the trace access hypothesis is the *cue familiarity* hypothesis. This position argues that feeling-of-knowing judgments rely on the familiarity of the cues in the questions themselves (e.g. Metcalfe, 1994; Metcalfe et al., 1993; Reder, 1987, 1988; Reder & Ritter, 1992; Schwartz & Metcalfe, 1992). In two arithmetic experiments, Reder and Ritter (1992) showed that subjects' feeling-of-knowing were based on the familiarity with configural features of the arithmetic problems instead of partial retrieval of the answer. Specifically, they trained subjects to know the answer to otherwise novel math problems such as 29 × 32 and found that similar-looking problems for which they did not know the answer were also likely to elicit a feeling-of-knowing. Indeed, the Reder and Ritter study independently manipulated familiarity with configural features of problems and answers and found that only the former predicted feeling-of-knowing. Schwartz and Metcalfe (1992) also provide evidence supporting the cue familiarity hypothesis. In an experiment where subjects were asked to recall the second pair of a rhyme associate, these researchers found that when subjects were asked to generate the second pair during study, their recall of the target item at test improved significantly while their feeling-of-knowing judgments were not affected. On the other hand, when subjects were primed with the cue during a pleasantness rating task, their recall of the target did not improve but their feeling-of-knowing ratings did.

So which hypothesis is correct: Trace access of cue familiarity? There is empirical evidence supporting both views. Thus, one can say that both hypotheses are correct (or wrong). However, we believe that this must be qualified by stating that the accuracy of the hypothesis depends on the methodology one uses to investigate feeling-of-knowing. If the researcher is investigating a feeling-of-knowing process that occurs after a memory retrieval failure, then it is likely that the feeling-of-knowing that is assessed is a by-product of the retrieval attempt. When the methodology is concerned with strategy selection, feeling-of-knowing turns out to be based solely on the cues of the question. Further, when conceptualized as a *rapid initial process* based on familiarity of the cues, feeling-of-knowing has functionality. In addition to the peripheral functions of predicting accuracy on a subsequent test or influencing search duration, conceptualizing feeling-of-knowing as an ongoing, rapid, initial process gives it the real-world functionality of affecting metacognitive behaviors such as strategy selection.

Functionality of rapid feeling-of-knowing

As discussed earlier, Hart (1965) showed that feeling-of-knowing judgments following retrieval failure are a good predictor of future performance on recognition tests. This finding has been substantiated many times by later researchers (e.g. Nelson & Narens, 1980; Nelson et al., 1984). It has also been shown that feeling-of-knowing ratings are correlated with search duration before responding "I don't know". However, these feeling-of-knowing judgments are assessed on only the subset of the items that are not answered correctly.

It seems to us that there is a more central function to feeling-of-knowing than just rating questions after the fact, specifically, to regulate strategy selection. It is important to emphasize that *rapid* feeling-of-knowing, assessed *before* retrieval failure, serves this function; the standard feeling-of-knowing judgment that is made after retrieval failure does not have this function. For example, when presented with a general knowledge question, a person can decide, based on this initial, rapid feeling-of-knowing, whether to try to retrieve the answer from memory or to use another strategy, such as reasoning or looking up the answer in a textbook. Similarly, after presentation of a novel math problem (e.g. 26 × 43), it would be this initial rapid feeling-of-knowing which would help a person decide either to retrieve or to calculate the answer. If the initial feeling-of-knowing for the problem is high, the person tries to retrieve the answer; if the feeling-of-knowing is low, the person computes the answer. Note that it is possible for the person to choose to compute even if the answer is stored in memory, and conversely, it is possible to choose to retrieve when the answer is not known. We will return to this point later.

What causes the feeling-of-knowing?

Given that a person makes an initial decision between retrieval and computation, we can see what underlies the initial rapid feeling-of-knowing process. We have provided evidence suggesting that familiarity with the terms in the question underlies this rapid feeling-of-knowing (Reder, 1987, 1988; Reder & Ritter, 1992; Schunn et al., 1997). Other researchers have also shown empirical support for the cue familiarity hypothesis (Schwartz & Metcalfe, 1992). Our research indicates that this feeling-of-knowing due to cue familiarity is achieved when configural properties, i.e. pairs of terms, have been seen before. Below we review the evidence that the rapid feeling-of-knowing process is based on the familiarity with question terms/pairs.[1]

Reder (1987) devised a game-show paradigm that illustrates the accuracy of this rapid feeling-of-knowing. Subjects were given questions of varying difficulty. In the "game-show" condition, subjects quickly estimated whether or not they could answer the question. Subjects were encouraged to respond as if competing against an imaginary competitor in a game show. When subjects indicated that they thought they knew the answer, they were required to give the answer, or at least try. If they responded that they did not know, the experiment continued with the next question. This provided a measure of how accurate their initial feeling-of-knowing had been. In a control condition, subjects were asked to respond with the answer as quickly as possible, or otherwise to respond "don't know." Note that this paradigm differs from the procedure used by Hart (1965) and other researchers (Nelson & Narens, 1980; Nelson et al., 1984) in two ways: First, subjects do not give their feeling-of-knowing judgments after failing to retrieve the answer; rather, they give a first impression of knowing for all questions. Second, they are never asked to judge how likely it is that they will be able to identify the correct answer on a subsequent recognition test.

Subjects were 25% faster to respond in the game-show condition than those in the rapid question answering control condition, a mean difference of over 700 milliseconds. Subjects in the Estimate (game-show) condition attempted to answer fewer questions than those in the Answer (control) condition; that is, though they attempted to answer fewer questions, they still answered the same absolute number of questions correctly. This meant that they were 10% more accurate in their judgments of what they knew. This is important because it indicates that the greater response speed of subjects in the Estimate condition was not the result of a speed-accuracy tradeoff.

An additional result from this same study further suggests that feeling-of-knowing is an ongoing process preceding all retrieval attempts, not just a by-product of tasks dreamed up by the experimenter. In Experiment 5, Reder (1987) found that the time for subjects in the Estimate condition first to give a strategy choice and then to give the answer was equal to the time for a subject simply to answer the question in the Answer condition.[2] This finding is consistent with the claim that the strategy choice process is a natural process preceding retrieval attempts.

In another set of related experiments using the game-show paradigm, Reder & Ritter (1992) and Schunn et al. (1997) have provided more empirical evidence for the cue familiarity hypothesis of rapid feeling-of-knowing. In these experiments, subjects were presented with novel arithmetic problems (ones for which the answer would not be known initially). They were asked to rapidly choose (in under 850 milliseconds) whether they would retrieve or compute the answer to the arithmetic problem. If they chose to retrieve, they were then required to give the answer within 1500 milliseconds. If they chose to compute, they were given ample time to calculate it.

Subjects were able to perform the task with little practice. To measure the appropriateness of the strategy choice, d' (Swets, 1986a, 1986b) and gamma (Nelson, 1984, 1986) scores were calculated where a hit was defined as selecting retrieval and answering within two seconds and a false alarm as selecting retrieval and not answering correctly within two seconds. Even at the beginning of the experiment, d' was 2.0 and gamma = 0.85, providing further support that rapid feeling-of-knowing is a metacognitive process which occurs prior to retrieval, that can be used with high accuracy to control strategy choice.

The findings just reviewed support the idea that a rapid feeling-of-knowing takes place prior to a retrieval stage. But what about the claim that rapid feeling-of-knowing is due to cue familiarity? Logically it should not be based on the answer if it occurs before retrieval; however this claim would be more convincing with converging evidence that supports cue familiarity. Reder and Ritter (1992) presented subjects with unfamiliar arithmetic problems, such as 29 × 32. At the beginning of the experiment when the problems were novel, subjects realized that their best choice would be to compute. However, over the course of the experiment, the level of exposure to the problems varied from one to 20 times. Thus, as the experiment progressed, subjects were able to learn the answers to the problems and could choose to retrieve. The payoffs were adjusted to encourage selection of the retrieval strategy when the answer could be given correctly in less than one second.

As the subjects began to learn the answers to some of the problems, during the final quarter of the experiment, they were presented with novel problems that resembled earlier problems. For example, if a subject was presented the problem 29 × 32 multiple times, 29 + 32 was presented. If feeling-of-knowing is based on partial retrieval of the answer, subjects should not be inclined to choose retrieval for this problem, since the answer is not already in memory. That is, the subject's feeling-of-knowing should not be any stronger for these test problems than for other genuinely new problems. On the other hand, if feeling-of-knowing is instead based on familiarity with the terms of the question, then subjects should be inclined to choose the retrieval strategy for these test problems because they look familiar. Frequencies of exposure to the entire problem and elements of the problem were varied independently, so it was possible to determine which contributed more to rapid feeling-of-knowing judgments.

As exposure to a given problem increased, subjects' tendency to choose retrieval increased. Over the course of the experiment, subjects were able to learn the answers to problems and could thus select retrieval appropriately, rather than need to compute. For the novel test problems, which consisted of well-practiced operand pairs with a new operator, subjects were equally likely to choose retrieval. In fact, the tendency to select retrieval was strictly a function of how often the operands had been seen together, and did not depend on whether the answer to the problem had been studied.

Although this result seems to provide evidence for a rapid pre-retrieval feeling-of-knowing based purely on cue familiarity, it may be that subjects actually attempted to retrieve the (wrong) answer first, and that their feeling-of-knowing was actually based on an early read of the answer to the problem that looked similar. To rule out this explanation, Schunn et al. (1997, Experiment 1) conducted a conceptual replication of the Reder and Ritter (1992) experiments. In this experiment, a portion of the problems were deemed "special", such that after subjects made the initial retrieve/compute decision, they were not allowed to actually retrieve or compute an answer. That is, after making the initial decision to retrieve or calculate, they were instructed to move on to the next problem. Importantly, subjects did occasionally give an answer to these "special" problems (specifically, one time out of seven, randomly determined). This was done to insure that subjects could not learn that these problems were never answered. The rationale for using special treatment of these problems was to independently vary exposure to problem and answer.

Given that familiarity with these special problems increased without a comparable increase in familiarity with the associated answers, we can test the target retrievability hypothesis more directly: subjects should be less likely to select the retrieval strategy for these special problems than for comparably exposed normal trials. However, if the cue familiarity hypothesis is correct, then subjects should select the retrieval strategy for these special problems at a rate predicted by the amount of time for which the problem was presented, not the answer. The results revealed that frequency of exposure to the problem rather than exposure to the answer predicted strategy choice.

Given all of the support for familiarity with problem features as the sole determinant of rapid feeling-of-knowing, we can ask how this mechanism might be formally implemented in a cognitive model of behavior. Below, we present a computational model of the tasks just described, fitting the simulation data to the human empirical data.

Mechanistic account of rapid feeling-of-knowing and strategy choice

The model is based on a generic semantic network model of memory called SAC, which stands for Source of Activation Confusion (see also Reder & Schunn, 1996; Reder & Gordon, 1997; Schunn et al., 1997). The model representation consists of interassociated nodes representing concepts that vary in long term strength. Applied to the arithmetic task, nodes represent the numbers, operators, and whole problems. There are links which connect the node for the whole problems to the operand, operator, and answer nodes. For example, for the problem 29 × 32, there would be a 29 × 32 problem node. Connected to this node would be the 29 and 32 operand nodes, the operator node ×, and the answer node 928.

Each node has a base-level or long term strength. The strength of a node represents the prior history of exposure to that concept. The more exposure the system has had to a concept, the greater the node's base-level strength. In the arithmetic game-show experiment, problems were assumed to have no pre-experimental familiarity (unlike problems such as 12 × 12), and problems were assumed to start out with the same low base-level strength.

Base-level strength (also called resting level of activation) increases and decreases according to a power function. This function captures the phenomenon of a quick initial decay of memories and the much slower decay at increasing delays for forgetting. Similarly, for learning, the power function reflects the fact that the first exposure to an item contributes more than do subsequent exposures.

In addition to the resting level of activation, each node also has a *current activation* level. This current level of activation will be higher than the resting level of activation whenever the concept receives stimulation from the environment. However, unlike the resting activation level, the current activation level decays rapidly and exponentially towards the base level, having effects only on the trial in which it was activated, and perhaps the trials immediately following.

The other class of assumptions concerns the links that connect the nodes to one another, e.g. the links connecting the components of the arithmetic problem to the entire problem, and the problem node to the answer node. The strength of a link that connects two nodes will depend on how often the two concepts (nodes) have been stimulated together. Just as link strength grows with stimulation, it decays with disuse, i.e. delay between exposures.

The current activation level of a node can increase as a result of environmental stimulation or if associated nodes send it activation. How much activation a node receives from associated nodes depends on the strength of the sending (source) node and the relative strength of the link from the source node to the receiving node. This relative strength of a link is determined by competition with other links emanating from the same source node.[3] This property also accounts for the data in fan effect paradigms (e.g. Anderson, 1974).

In this spreading activation model, it is the activation level of the problem node that determines feeling-of-knowing. In essence, feeling-of-knowing is a process that monitors the intersection of activation from two source nodes. When two terms of a question send out activation to associated concepts, and an intersection of activation is detected by bringing an intermediate node over threshold, a person will have a feeling-of-knowing response.

Below, we present some comparisons between the simulation of the arithmetic task described above and the empirical data. An aggregation procedure developed by Anderson (1990) was used to compare the model's predictions to subjects' actual retrieve/compute decisions. For each trial, for each subject, the model produced a probability of choosing retrieval based on the calculated activation values resulting from the trial history for that subject. Trials were aggregated based on the predicted probability of selecting retrieval. Those probabilities were compared with the observed proportion of trials where retrieval was selected for that subset.[4]

For the Reder and Ritter data set, the model fits the data quite well, producing a Pearson r of 0.990 (see Figure 3.1a). Recall that the model also predicts that subjects would also be as likely to select retrieval for operator-switch problems as for training problems. The model predicts this effect because operators are associated with a large number of problems and, due to the large fan, the model predicts that there will be little impact of switching operators on retrieve/compute decisions because the activation of the problem nodes is not significantly affected. The fit of the model to the operator-switch retrieval data is quite good (r = 0.981). Figure 3.1b presents this fit.

Earlier in the chapter, we referred to Experiment 1 of Schunn et al. which showed that rapid first impressions (i.e. rapid decisions to retrieve) were based on familiarity with the problem rather than associative strength of the answer. Using the same parameter values as in the Reder and Ritter simulation, with the exception of the individual subject thresholds parameter,[5] the fit of the simulation for this data set were still impressive (r = 0.994). The fit of the simulation's predictions to the subject performance is shown in Figure 3.2.

Reconciling theoretical differences

Koriat (1993, 1995) has argued that feeling-of-knowing is based not on familiarity with the probe, but rather on the accessibility of partial information related to the target. Specifically, he argues that the sum of the information pertaining to the target as a result of a retrieval process determines the judgment.

Koriat presents some empirical findings to support this claim. Koriat (1993) required subjects to learn nonsense letter strings (e.g. TLBN). The procedure basically conforms to the recall–judgment–recognition paradigm introduced by Hart (1965) with the following exceptions. First, feeling-of-knowing judgments were always solicited regardless of the subject's performance on the initial recall test. Second, subjects were not forced to report everything they studied; instead, they were given the option of reporting as many letters as they could remember. Each trial began with four Stroop items followed by the target string. Then subjects did more Stroop items for 18 seconds before being asked to recall the target string. After attempting to recall as many letters as possible, subjects gave a feeling-of-knowing judgment for the presented target string on a 100-point scale. Immediately following this, a recognition test with eight alternatives was administered. A

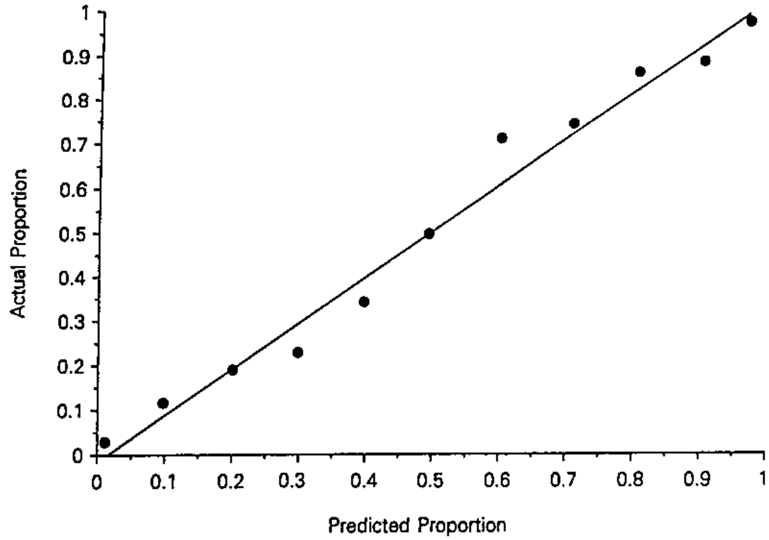

Figure 3.1a *Predicted vs. actual proportion of retrieval strategy selections in Reder and Ritter, grouped by predicted proportion for all problems (from Reder & Schunn, 1996)*

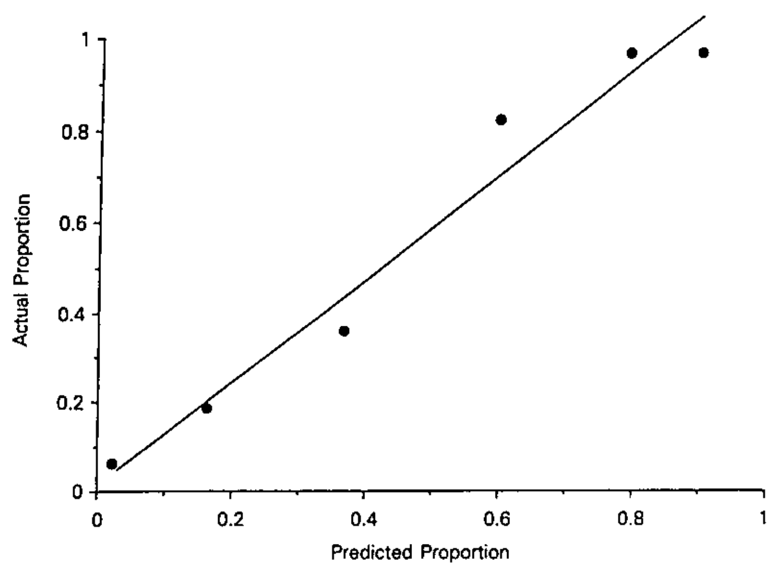

Figure 3.1b *Predicted vs. actual proportion of retrieval strategy selections in Reder and Ritter, grouped by predicted proportion, for the operator-switch problems only (from Reder & Schunn, 1996)*

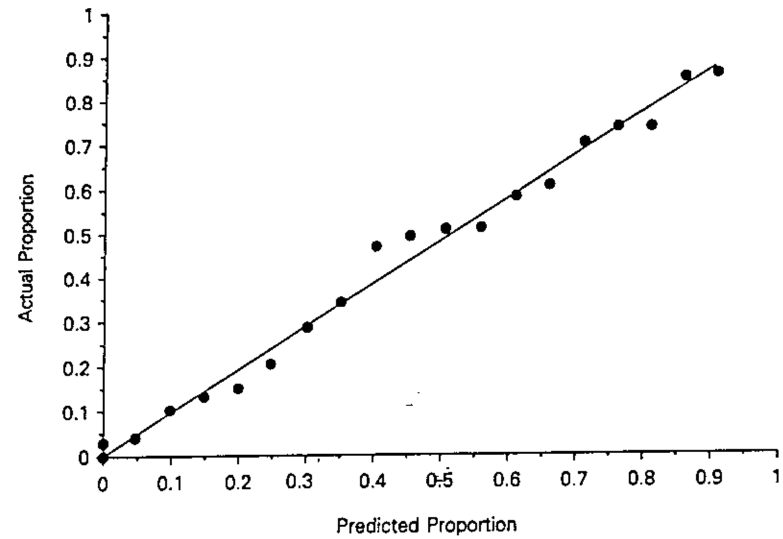

Figure 3.2 *Predicted vs. actual proportion of retrieval strategy selections in Experiment 1 of Schunn et al., grouped by predicted proportion, for all problems (from Reder & Schunn, 1996)*

unique feature of this recognition test was that the correct alternative in the recognition test was a random ordering of the correct four letters (e.g. if target was FKDR, the correct choice could have been RDFK). The results from two nonsense letter string experiments showed that feeling-of-knowing judgments increased with the amount of information recalled regardless of the accuracy of that information. Specifically, feeling-of-knowing judgments were highly correlated with the number of correct and incorrect letters the subjects were able to report.

It is noteworthy that subjects were not encouraged to chunk the letter strings as one item: the letters could come in any order in the recognition test. In our view, this means that subjects were not really asked for a feeling-of-knowing for an *answer*. Instead, they were asked for a feeling of being able to report *all of the letters*. Accordingly, this task seems artificial. Most feeling-of-knowing experiments are concerned with recalling one answer, not four letters in any order. Therefore, the experiment just described does not provide a good test of the target accessibility versus cue familiarity hypotheses. Unlike experiments that use questions and answers or even paired associates, this experiment treated the cue and the target as one and the same. Consequently, it is difficult to say whether the high feeling-of-knowing was due to a strong cue or a strong target.

Koriat (1995) also acknowledged the restrictive nature and artificiality of the letter string recall task. Addressing this problem was one of the goals of his more recent paper. The newer experiments involved asking subjects general knowledge questions, followed by feeling-of-knowing judgments. In the first experiment, subjects were asked general knowledge questions one at a time and were told to write down the answer if they knew it. They were also asked to give a judgment of how likely it was that they would be able to identify the correct answer among four distractors. The recognition test was administered immediately after all of the questions had been presented.

In a second experiment, Koriat (1995) attempted to investigate a preliminary feeling-of-knowing similar to the process investigated in the rapid game-show paradigm used by Reder and her colleagues. In this experiment, subjects were told to provide a *fast, prospective* feeling-of-knowing judgment after each question was read. They were asked to estimate the probability of being able to select the correct answer between two alternatives. They were instructed not to make a deliberate attempt to search for the answer. However, if the answer came to mind within this "fast" estimation period of five seconds, they were to write it down instead. The two-alternative-choice recognition test was given immediately after all of the questions were asked.

To support his argument that feeling-of-knowing judgments are based on the accessibility of the answer, Koriat showed that subjects' feeling-of-knowing judgments in these general-knowledge-question experiments were correlated with the accessibility of the answer. An accessibility index was calculated for each question, where the accessibility index was defined as the percentage of subjects reporting an answer, both correct or incorrect, to each question. Each memory pointer (i.e. answer to a general knowledge question) was then classified as either high or low in accessibility. The main finding from these experiments was that feeling-of-knowing judgments, irrespective of whether solicited prospectively or retrospectively, were highly correlated with the accessibility index. That is, subjects gave a high feeling-of-knowing for highly accessible targets and a low feeling-of-knowing for targets classified as less accessible.

Note that the findings from these experiments are only correlational, i.e. a subject who gives a high feeling-of-knowing is not the same subject who retrieves the answer. However, the pattern of questions producing one or the other is reasonably strong across subjects. These correlational data do not provide as strong evidence as a direct within-subjects experimental manipulation that shows that the frequency of the cues (familiarity) leads to a higher feeling-of-knowing. In the game-show paradigm with either general knowledge questions or arithmetic problems, we can manipulate a subject's feeling-of-knowing through prior exposure or familiarization with compound cues from a query. We can do this without affecting the subject's knowledge base. This random assignment of materials to condition for each subject seems a stronger test than a correlational result that is more vulnerable to alternative interpretations. Even if Koriat's interpretation of his data is correct, his model cannot explain our data.

Assuming that Koriat's data are correctly interpreted, why then are his data, using a similar game-show paradigm, inconsistent with ours? That is, why does he find evidence of partial retrieval influencing feeling-of-knowing? It may be because his subjects have *already attempted* a retrieval. His definition of rapid feeling-of-knowing is not very rapid and we doubt that it is a pre-retrieval estimation. Reder's subjects gave their judgments in under one second, which was not enough time to retrieve (Staszewski, 1988). In contrast, Koriat's subjects were given up to five seconds to make a judgment. Furthermore, by allowing subjects to write down the answer if it came to them, without imposing a quick deadline, there is no insurance that subjects did not attempt to retrieve the answer before giving their feeling-of-knowing judgments. Therefore, considering his subjects' performance as representative of a rapid feeling-of-knowing seems inappropriate.

One stage or two for feeling-of-knowing?

In light of his results, Koriat (1995) proposes that the same continuous stage can account for both rapid pre-retrieval feeling-of-knowing and post-retrieval-failure feeling-of-knowing. This continuous, integrative monitoring and retrieval process is updated on-line, and can influence search duration. Thus, this continuous process of monitoring and retrieving has predictive validity and can influence search duration. Koriat questions why we would need a separate pre-retrieval feeling-of-knowing stage since the continuous accessibility model accounts for both pre-retrieval and post-retrieval feeling-of-knowing. For parsimony's sake, he further questions the value added of a system that first computes feeling-of-knowing before simply attempting to retrieve; he argues that a continuous retrieval process can account for both.

We can respond to this in two ways. First, the value added by a pre-retrieval or pre-strategy execution stage was shown in Reder (1982), and reviewed above. To repeat, it is clear that subjects do not always attempt retrieval, and sometimes they use other strategies. This has also been shown by Lemaire & Reder (under review) and in the other studies reviewed earlier. Given that subjects do not always execute a retrieval strategy, it is reasonable to posit a stage in which such strategy selection decisions are made.

It is also clear from these studies that strategy choice is not simply a competition between two parallel procedures. Rather, subjects exhibit a preference for one strategy. Lovett & Anderson (1996) have reported similar findings. We cannot rule out a parallel, but biased (in terms of allocation of resources) competition; however, there still must be a mechanism that selects this bias from trial to trial. Furthermore, the similar data of Lovett and Anderson seem more difficult to accommodate with an assumption of biased competition (as opposed to a serial execution).

One still might ask, like Koriat, how humans could evolve to inspect memory, i.e. use feeling-of-knowing in order to decide whether to carefully inspect memory, that is, conduct a specific retrieval of an answer. The model that we described briefly above provides an answer to this conundrum: Feeling-of-knowing is automatically represented in the parsing and representation of the problem or question (not the elements, per se). In other words, the rapid, preliminary feeling-of-knowing stage necessarily occurs before the retrieval attempt, because it is a product of parsing the question. Consequently, feeling-of-knowing is a natural precursor to the retrieval process.

Conclusion

The aim of this chapter has been to clarify the different views regarding feeling-of-knowing. We reviewed the work of researchers looking at feeling-of-knowing in the post-memory-retrieval-failure paradigm. There is strong evidence that judgments made after a retrieval failure have predictive validity for subsequent recognition. These judgments are also correlated with length of search before termination. We also reviewed work from our lab that looked at feeling-of-knowing as a judgment that precedes execution of question-answering strategies. Specifically, we believe feeling-of-knowing is a process which utilizes compound cue familiarity to regulate strategy selection. In summary, the difference in perspectives and findings between feeling-of-knowing researchers stems from the fact that two different processes are being compared: post-retrieval-failure feeling-of-knowing, and rapid pre-retrieval feeling-of-knowing.

The predictive validity of feeling-of-knowing judgments in this paradigm is much higher than in the conventional paradigm (d' = 2.0 vs. 1.0, and gamma = 0.85 vs. 0.62). This is partly due to the non-restricted range of judging all questions (see Reder & Ritter, 1992 for a fuller discussion), but it is also due to the fact that the task is more natural. Our thesis has been that feeling-of-knowing is a typically unconscious judgment that directs strategy use (Reder & Schunn, 1996). In everyday life, people only become aware of these feelings-of-knowing when there continues to be a strong feeling-of-knowing alongside lack of search success, i.e. a tip-of-the-tongue state.

In the context of the rapid assessment of whether to begin search (as opposed to using another strategy, such as reasoning or calculation), only the familiarity of the elements of the query or problem is assessed.[6] In contrast, after retrieval has been selected and search has commenced, other attributes no doubt influence how long search continues. These variables also influence the feeling-of-knowing judgments that are made after memory retrieval failure, e.g. partial products of retrieval attempts.

Notes

1. The Schwartz and Metcalfe (1992) evidence is not from a rapid paradigm and was after a memory retrieval failure. Further, we only find the effect with pairs, so we do not wish to comment on their results.

2. Subjects in both conditions responded by pushing one of two buttons. This manipulation controlled for any possible advantages due to the short binary responses (i.e. "yes" or "no") in the Estimate condition over the word responses (e.g. "baseball") in the Answer condition. Consequently, subjects in both groups made binary decisions prior to giving the answer.
3. Thus, the absolute magnitude of the link strength is irrelevant. It is the strength relative to the total strength of the other links that really matters.
4. Refer to Schunn et al. for detailed description of modeling procedure.
5. Refer to Schunn et al. for all parameters and the values used in simulations.
6. By this we mean a higher-level representation of the integration of the query elements. What we do not mean is the elements in isolation or the answer.

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4

The Feeling-of-Knowing as a Judgment

Guy Lories and Marie-Anne Schelstraete

The question answering situation

The feeling-of-knowing paradigm

How we answer simple, factual questions involves more complexities than one would expect. We should wonder, for instance, why we keep searching for an answer we do not find immediately, how we know we do not know something (Glucksberg & McCloskey, 1981; Kolers & Palef, 1976), why we start searching at all (Miner & Reder, 1994; Reder, 1987, 1988; Reder & Ritter, 1992) or what makes us confident in some response we have been able to come up with (Koriat, 1993; Koriat, Lichtenstein, & Fischoff, 1980). All the above points are somehow related to metacognition, that is, to the more or less explicit knowledge we have of the way our memory and our mind work.

Research has shown that human subjects can express a number of more or less valid judgments about various aspects of experimental cognitive tasks; they can express, for instance, judgments of learning or judgments of comprehension that correlate under appropriate conditions with actual learning or comprehension. Research also suggests that these judgments are more or less directly related to the optimization of cognitive processes, determining how long one will search for an answer, keep rehearsing when learning, etc. (Miner & Reder, 1994; Reder & Ritter, 1992).

In this chapter, we will only deal with the feeling-of-knowing judgment (see Nelson, 1996 or Schwartz, 1994 for a general review of metacognition). The feeling-of-knowing is a judgment that subjects make regarding their ability to recognize or recall some information that is not accessible at the time the judgment is made. It is somewhat different from the well-known tip-of-the tongue phenomenon because no reference is made to the very specific, phenomenologically strong experience the tip-of-the tongue phenomenon implies (see Smith, 1994 for a discussion of the relationship between the feeling-of-knowing and the tip-of-the tongue). A review of the feeling-of-knowing literature can be found in Koriat (1993; and Chapter 2 in this volume), Nelson and Narens (1990) or Nhouyvanisvong and Reder (Chapter 3 in this volume).