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Subthreshold Priming and Memory Monitoring

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Priming is thought to produce a nonconscious form of human memory. This form of memory has been intensively studied over the past 15 years, and recently Tulving and Schacter (1990) proposed it as a subsystem of human memory on a par with procedural, semantic, and episodic memory. The relation between this nonconscious form of memory and metacognitive judgments derived from conscious introspection has also been an issue of recent study. This chapter describes research concerning the influence of subthreshold as well as conscious priming on (1) recall, (2) subjective evaluation of knowing answers to questions, and (3) subjective evaluation of learning. The empirical findings show different patterns of results for evaluations of knowing and evaluations of learning. A theory is presented that explains these patterns in terms of differences in putative strategies used to relate the evaluations of knowing and learning to later performance tests.

Subthreshold Priming

In the subthreshold priming and other priming paradigms described below, the subject is presented with information, called a *prime,* prior to taking a recall test on the item and/or prior to making metacognitive judgments about the item. The primes are of three types: (1) a *cue prime* (i.e., information about the question in a general information test or the stimulus in a paired-associate test), (2) a *target prime* (i.e., information about the answer in a general information test or the response in a paired-associate test), and (3) a *neutral prime* (i.e., no information or neutral information provided by a nonsense word with phonological characteristics typical of English words). The effect of cue or target priming on a metacognitive judgment is determined by comparing the mean (or median) of the judgment's ratings for the cue or target primed items with the mean (or median) of its ratings for the neutrally primed (control) items. Primes may be presented to subjects in a variety of manners. Sometimes they are presented prior to the recall task in a supposedly unrelated phase of the experiment. But sometimes, and these cases will be of particular interest here, they may be presented below a perceptual threshold by using a variant of a technique developed by Marcel (1983).

Marcel (1983) presented words to subjects using tachistoscopic flashes of such brief durations that they reported complete unawareness of the information being flashed. He showed that despite their inability to know whether a word had been presented, subjects' subsequent cognitive behaviors were altered in a variety of ways by the presentation. It is plausible that although subjects in these kinds of experiments report being unaware of the presented information, they nevertheless may be capable of being aware of various effects due to the presented information. It is of considerable importance for metacognitive theory to determine which kinds of effects can be monitored and which kinds cannot. This chapter presents empirical findings and a theory about the metacognitive monitoring of such effects on learning and memory.

In the experiments discussed below, two different methods of subthreshold priming are used. The aim of the first subthreshold priming method is to ensure that subjects cannot consciously read information presented. Since each individual differs in terms of the amount of time needed for conscious detection of visually displayed information, each subject's visual threshold must be individually determined. To do this numerous presentations are visually flashed. Each presentation consists of a word followed by a pattern mask and the subject is asked to name the presented word. The duration of the pattern mask is fixed throughout. For each subject the initial word presentation is at a fixed brief duration. If the subject correctly identifies the word, the duration of the next word is shortened. This continues until a duration is found for which the subject is not able to identify a word flashed at that duration. Once this duration is found, the next durations are gradually lengthened until the subject correctly identifies another flashed word. Then the durations are again slightly shortened every time the subject correctly identifies a flashed word, until a duration is found such that the subject is unable to identify a specific number of consecutive words, e.g., eight words. This last duration is called the subject's *threshold time.* The subject's *subthreshold presentation time* is the duration that items are presented to the subject for the remainder of the experiment. This is defined as a certain percentage (e.g., 90%) of the threshold time. Individual subthreshold presentation times are determined for each subject. In pilot experiments and experimental debriefing, subjects reported being unaware of the content of the information being flashed at subthreshold presentation times.

One question addressed in this chapter is whether and in what manner subthreshold (and, in some cases, superthreshold) priming influences metacognitive assessments. However, before this issue can be properly addressed, it is necessary to be more specific about the nature of the judgments themselves. As will be discussed later, different kinds of metacognitive judgments may be differentially susceptible to the influence of cue and target priming manipulations. To disentangle and analyze these effects it is important to distinguish among the several kinds of metacognitive judgments.

Metacognitive Judgments

In the experimental study of the monitoring and control of memory processes, three kinds of related judgments have played a prominent role: feeling-of-knowing (FOK) judgments, confidence judgments, and judgments of learning (JOLs). In the Nelson–Narens theoretical framework for metamemory (Nelson & Narens, 1990), each of these judgments corresponds to a specific theoretical metamemory decision process. FOK judgments correspond to decisions to continue searching during retrieval, confidence judgments correspond to decisions to output answers during retrieval, and judgments of learning correspond to decisions to control the amount of study during learning.

In experimental settings, FOK and Confidence judgments are made after a recall test. *FOK judgments* are about incorrectly recalled items. Incorrect items arise either through omission errors where the subject gives a "don't know" response, or through commission errors where the subject gives an incorrect answer. *Confidence judgments* are made about correctly recalled items and commission errors. In the case of omission errors, the subject has only metacognitive information about the question and the retrieval process (including the fact that no answer was produced) on which to base his or her FOK judgment. In the cases of correct responses and commission errors, the subject can use information about the produced "answer" as well as information about the question and the retrieval of this answer in making a confidence or FOK judgment.

Confidence judgments are usually framed and formulated as judgments about some recent action *in the past* (e.g., how confident the subject is that he or she gave the correct answer), whereas FOK judgments are usually formulated as judgments about some *future* action (e.g., how well the subject will do on the item in a future test).

These differences between FOK and confidence judgments prompted metamemory researchers to analyze them separately, and some researchers (e.g., Krinsky & Nelson, 1985) further distinguish FOK judgments by whether they are based on commission or omission errors. However, for the kind of priming experiments considered in this article, such separate analyses of the data often produce difficulties, and the *combination* of FOK and confidence judgments are often the appropriate metacognitive judgments to consider. This combination is designated *FOK/C* (figure 4.1). In obtaining FOK/C judgments, the same question is asked of the subject regarding both incorrect and correct answers (e.g., "Rate how likely you are to recognize the answer on a multiple-choice test") so that the FOK and confidence judgments can be compared.

JOLs are based on information about the learning of the item as well as information about the retrieval/nonretrieval of the answer. JOLs are made about some future action, and unlike FOK and Confidence judgments, JOLs are often made without a prior recall test.

Most FOK studies have been conducted using general information questions. Presumably the vast majority of these items were learned long before testing (usually years before testing). Thus for most of

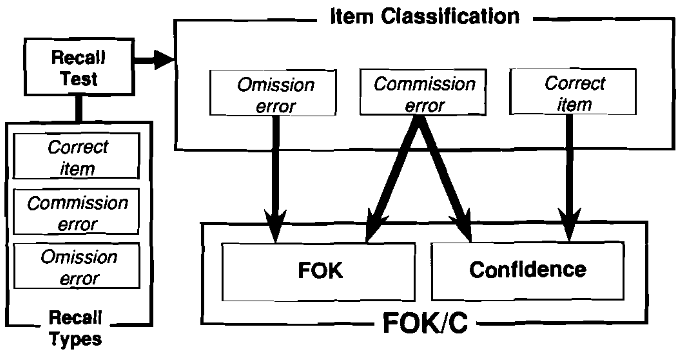

Figure 4.1
Definition of FOK/C judgments.

these items substantial time has passed between learning and the FOK judgment. In contrast, most JOL studies have been conducted using recently learned paired-associates of familiar words with lapses between learning and JOL ranging from less than 1 second to a few minutes.

A Methodological Consideration

A potential methodological pitfall in determining the effect of cue or target priming on FOK arises because priming can affect the recallability of items, and FOK judgments are made on only a portion of the items, those items that are nonrecalled. The following thought experiment illustrates the difficulty (see also Lee, Narens, & Nelson, 1993).

Suppose that a particular form of target priming does not affect an item's FOK rating, that is, if the item were nonrecalled then it would receive the same FOK rating under target priming as under neutral priming. Call an item a *potentially high FOK item* if and only if it would have a high FOK rating when neutrally primed. Now, also suppose that target priming causes potentially high FOK items to be recalled while having no effect on the recallability of other items (figure 4.2). Then given enough items and the random assignment of items to the target and neutral priming conditions, one would expect to observe the mean (or median) of FOK ratings for target

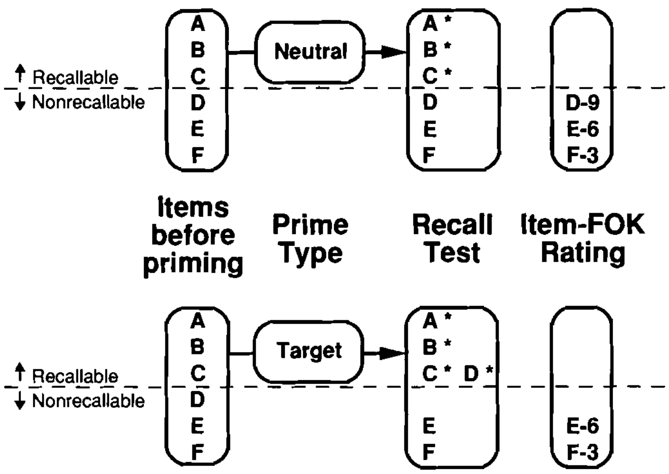

Figure 4.2
A possible influence of priming on FOK judgments and recall. Letters represent items. Items with asterisks represent correctly recalled items. Numbers represent FOK ratings on a scale of 1 to 9, with 9 the highest rating. **D** is a potentially high FOK item.

primed items to be *less than* the mean (or median) for neutrally primed items. But by construction, *target priming is not affecting the FOK of any given item. It is affecting only which items are nonrecalled.*

The potential for this methodological pitfall exists whenever the relevant priming conditions produce different effects on recall. One way to avoid this methodological pitfall is to measure the effect of priming on FOK/C instead of FOK. When FOK/C is used for this purpose, it is important that the subject is asked to make the same kind of judgment for both correctly and incorrectly recalled items in order that the judgments for correctly and incorrectly recalled items can be compared. Thus a subject could be asked to "rate how well you think you will do on this item in a six-alternative multiple-choice test," or to "rate how much you feel you know the answer to this question," etc. The important consideration is that the subject is asked the same question about each item.

Some studies in the literature on priming and FOK do not take this pitfall into account. For these studies we report only findings for which the priming did not produce a significant effect on recall. Even with this restriction, the potential for the above methodological pitfall remains if the magnitude of the effect of the cue or target prime is not large (see Lee et al., 1993, for a discussion).

Subthreshold Priming Research and Judgments of Knowing

FOK and Perceptual Identification

Nelson, Gerler, and Narens (1984) investigated (1) the effect of subthreshold target priming on the perceptual identification of non-recalled answers to general information questions, and (2) the relationship between priming and the FOK. In the first phase of the experiment, each subject was presented with a series of general information questions and asked to search their memory "hard in an attempt to find the answer," until a specific number of questions were answered incorrectly. Each subject then made an FOK judgment for each incorrectly answered question. In the next phase of the experiment the subject was presented with two screens. On the first screen, an incorrectly answered question was displayed. The subject was told that on the second screen the answer to the question would be flashed, and he or she should try to identify the flashed answer. Initially the answer, followed by a fixed-duration pattern mask, was flashed at a far too brief of an interval for the subject to identify. However, in subsequent presentations the answer duration was incremented by a small fixed amount until the subject was able to give the correct answer. The number of flashes to correct identification was one dependent variable of interest.

The main finding of interest was that items with high FOK ranks were correctly identified in fewer flashes than those with low FOK ranks. This result was found even when the effect of reminiscence was taken into account.[1] Thus, the Nelson et al.'s (1984) findings indicated that whatever FOK was monitoring influenced the power of the subthreshold primes to make the answers available to the subject. This raised an interesting question about the converse — namely, does subthreshold priming influence FOK?

FOK/C and Recall

Jameson, Narens, Goldfarb, and Nelson (1990) designed experiments to address the question of whether subthreshold primes might influence FOK judgments. They thought that Nelson et al.'s (1984) perceptual identification results might have been due to the incremental subthreshold flashes having a priming effect on memory retrieval: "whatever produced the high FOK also caused the prime to have a greater effect on memory performance" as measured by perceptual identification (p. 56). Jameson et al. (1990) also noted that this explanation was in accord with a model of metamemory proposed by Hart (1965a, 1967b), which implies that FOK is a more sensitive indicator of memory content than recall.

This suggests that in the Nelson et al. (1984) perceptual identification task FOK monitored memory strength, and items with greater memory strength were given a greater FOK ranking. If high FOK items were the (nonrecallable) items with strengths near threshold, and subthreshold priming (from the degraded presentation) only added small increments to memory strength, then it explains why the items that became identifiable through small amounts of subthreshold priming were those with high FOKs. Taking into account Hart's suggestion that FOK is a more sensitive indicator of memory strength than recall, Jameson et al. (1990) hypothesized that FOK may be able to monitor small increments in memory strength below the threshold for retrievability. They decided to directly test this.[2]

Jameson et al.'s (1990) experimental paradigm consisted of two sessions. In the first session, the subject participated in a recall test using general information questions. Incorrectly recalled items from this session were used in the second session, 1 week later. At the beginning of the second session, each subject's threshold time was determined (using the procedure discussed earlier) and the subthreshold[3] presentation time was established at 90% of the threshold time. Then each subject was presented with the sequence of events depicted in figure 4.3 for each question incorrectly recalled during the first session.

Jameson et al. (1990) found that subthreshold target priming increased recall 18% while having no effect on FOK/C judgments. In

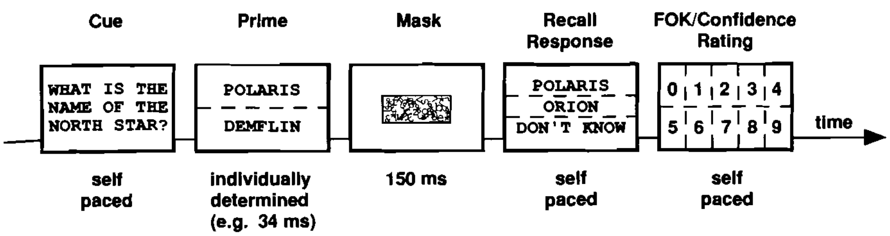

Figure 4.3
A typical sequence for session 2 of Jameson et al. Cue = "WHAT IS THE NAME OF THE NORTH STAR?" Prime = either the target, "POLARIS," or a nonsense word, "DEMFLIN." Recall response = either the correct answer, "POLARIS," an incorrect answer, e.g., "ORION," or a "DON'T KNOW" response.

a second experiment, identical to the first except that the recall stage of the second session was omitted and the FOK/C judgment was made immediately after priming, priming again produced no effect on FOK/C judgments. These results demonstrated that an increase in recall performance occurred following a subthreshold answer prime as compared to a neutral prime (in experiment 1), but no effect of prime type on FOK/C was found (in experiments 1 and 2). Jameson et al. (1990) concluded that these results contradicted the then generally accepted hypothesis of Hart (1967b) and many others that FOK/C is more sensitive than recall at detecting information in memory. Their results demonstrated that the opposite can occur — in particular, that recall is better than FOK at detecting the perceptual input from a subthreshold prime.

Jameson et al. (1990) suggested that their findings also imply that there are at least two distinct memory processes involved in facilitating recall. They theorized that

> An item in memory that is below the retrieval threshold may have a subthreshold amount of information in memory that is accessed by the FOK. Then if useful information (e.g., semantically related prime, contextual information, etc.) about the item is contributed to the system by way of the perceptual input that is not monitored by the metamemory system, then these two kinds of information — one detected by the metamemory system and the other not — can combine to raise the item above the retrieval threshold so that it becomes recalled. (pp. 63–64).

They then used this theory to provide the following explanation for the Nelson et al.'s (1984) subthreshold priming perceptual identification result:

> The Nelson et al. (1984) finding that high FOK predicted better performance on a subsequent perceptual identification task can be interpreted as follows: Suppose a subject reports a high FOK for the subsequent recognition of a nonrecalled item, which in theory indicates an awareness of relevant information in memory that does not exceed the retrieval threshold. Further suppose that the perceptual input from a prime contributes some amount of information, which in itself is not sufficient to produce identification. Then, according to the 'combining notion', it is possible for these two amounts of information to combine to surpass the identification threshold (perhaps by surpassing the retrieval threshold), and as a result, perceptual identification is facilitated for items previously given a high FOK. An analogous explanation can be made for the failure of items given low FOK ratings to be identified. (p. 65)

In summary, Jameson et al. (1990) provided (1) a theoretical context in which to interpret the above findings of Nelson et al. (1984), and (2) an important empirical demonstration of a situation in which subthreshold priming influenced memory performance but not FOK/C.

Related Superthreshold Priming Research

It has been known for some time that recognition for cues can influence a subject's feeling of knowing for nonrecalled targets. For example, Wellman (1977) showed that kindergartners used information about having seen the cue in making FOK judgments about nonrecalled targets, and Koriat and Lieblich (1977) showed that the addition of redundancy to the cue through repetition or adding alternative wording increased subjects' ratings for nonrecalled targets. Additional findings discussed here are the results of Reder, Metcalfe, Schwartz, and Schwartz and Metcalfe.

Cue Priming Effects on Rapid Judgments of Knowing and Rapid Recall

Reder (1987, 1988) investigated the effects of cue priming on metacognitive judgments that are similar to FOK judgments. In the first stage of her experiment, subjects made frequency-of-occurrence estimations for words that would be later used in some question parts of a series of general information questions. The words chosen were central to the question later presented in the general information test. For example, in a question like "What is the term in golf for scoring one under par?" the words "golf" and "par" would be selected. After the word frequency estimation task, the subjects participated in either an "estimate condition" or an "answer condition" of a *game show paradigm.* This paradigm requires subjects to make fast estimates about their ability to answer general information questions before they are able to retrieve the answer. It is modeled on television game shows where the first contestant to press a buzzer gets first chance at answering the question, and where the most successful contestants often press the buzzer before hearing the entire question. Subjects in the *estimate condition* were asked to give rapid first impressions about whether they could subsequently answer general information questions. By pressing a "Yes" button they indicated they thought they could answer the given question, and by pressing a "No" button they indicated they thought that they could not. Subjects in the *answer condition* were asked to immediately answer the question.

In both conditions priming produced an elevated propensity to attempt answers to questions. In the estimate condition, subjects pressed the "Yes" button more often to primed questions than to unprimed ones, indicating they thought they could correctly answer more primed questions than unprimed questions. In the answer condition, subjects searched longer for answers to primed than unprimed questions before saying "Don't know," indicating that during retrieval they thought they knew the answers to primed questions better than to unprimed questions. Reder (1987, 1988) describes both kinds of priming effects as "spurious Feelings of Knowing."

Reder also found the unexpected result that priming influenced the probability of subjects correctly answering questions:

> There seemed to be a tendency for subjects to respond more accurately in the answer condition when the question had been primed than when it had not been primed. Conceivably, priming the terms of a question not only gives one a feeling of knowing but actually raises the level of activation for relevant information such that the answer is more likely to pass over some kind of threshold necessary to elicit an answer. (Reder, 1988, pp. 253–254)

In an intricate series of experiments, Reder and Ritter (1992) investigated the kinds of information that subjects use in making rapid strategy selections. Their research produced a number of interesting and important findings, including ones that demonstrate that cue priming but not target priming influences strategy selections. They use this result to theorize that cue priming but not target priming influences the FOK.

Cue and Target Priming Effects on FOK for Learned Paired Associates

Metcalfe (1993) and Schwartz and Metcalfe (1992) interpret the above results of the Jameson et al. (1990) and Reder (1987) experiments as evidence against the *target retrievability hypothesis* for FOK, which states that FOK is based on the retrieval of information about the target. Instead, they interpret these findings as evidence for the *cue familiarity hypothesis* for FOK, which states that FOK is based on the familiarity or recognizability of the cue. Schwartz and Metcalfe (1992) and Schwartz (1992) designed a series of experiments to test these alternative hypotheses in a priming context.

Their experimental paradigm contained the following stages: First, there was a *priming phase* in which subjects were asked to rate words in terms of pleasantness. Some of these words were used later in the experiment. Second, there was an *encoding phase* in which subjects learned pairs of words for cued recall. These pairs consisted of words that the subject rated in the priming phase — *primed* words — and new words not previously rated by the subject — *unprimed* words. In two experiments, Schwartz and Metcalfe (1992) used primed and unprimed words as cues and unprimed words as targets; in another experiment by Schwartz and Metcalfe (1992) and an experiment by Schwartz (1992), primed and unprimed words appeared as either cues or targets, and each pair included at least one unprimed element. Third, a *cued recall* test was given in which the subject was presented with a cue part of an encoded pair and was asked to recall the target part of the pair. And finally, an *FOK judgment phase* was presented in which subjects were asked to make FOK judgments estimating how well they would recognize the answer when shown the cue word of an unrecalled pair.

The essential findings of these studies (Schwartz & Metcalfe, 1992; Schwartz, 1992) for the issues of this chapter can be summarized as follows:

- In the four experiments using unprimed targets, the FOK ratings for items with primed cues were higher than for items with unprimed cues. In three of these experiments, the recall of items with primed cues was the same as the recall of items with unprimed cues.
- In the two experiments using primed and unprimed targets, the FOK ratings for items with unprimed cues and primed targets were the same as for items with unprimed cues with unprimed targets. In one of these experiments, the recall of items with primed targets was the same as the recall of items with unprimed targets. In the other experiment, recall was greater for items with primed targets.

Although they argued against the target retrievability hypothesis, Schwartz and Metcalfe (1992) and Schwartz (1992) did not take into account in the interpretation of their findings the methodological difficulties discussed earlier concerning measuring the effect of priming on FOK when recall is affected by the priming. The above summary of their results contains only results in which priming had no effect on recall. This limited portion of their research indicates that (1) cue priming can have a significant effect on FOK without having a significant effect on recall; and (2) cue priming can have a significant effect on FOK without target priming having a significant effect on FOK. However, this limited portion does not contain direct evidence against the target retrievability hypothesis. Their evidence against the target retrievability hypothesis is greatly weakened by not taking into account methodological considerations discussed earlier.

For nonrecalled items, increasing or decreasing the information used in retrieval without correspondingly increasing or decreasing FOK ratings would provide *direct* evidence against the target retrievability hypothesis. However, we would generally expect an increase or decrease in information used in retrieval to produce a corresponding increase or decrease in recall. But as discussed earlier, a change in recall performance due to priming makes it difficult to compare the influence of priming on retrievability of unrecalled items with the influence of priming on FOK ratings. If no change in recall is observed, we can still test for a change in the retrievability of unrecalled items by using more sensitive tests, e.g., using recognition or relearning. This was done by Schwartz and Metcalfe (1992). They observed that cue priming increased FOK ratings, target priming left FOK ratings unchanged, and both cue and target priming left recall performance unchanged. In this experiment, a recognition test was given after each subject made FOK ratings. In the recognition test, the subject was presented with cues for unrecalled items. For each cue the subject was asked to choose the word associated with that cue from a list of words . They found that primed targets were more likely to be recognized on this test than unprimed targets.

Unfortunately, due to the nature of the recognition test employed, we believe that this result does not demonstrate increased use of primed information in the retrievability of items. The choices in the recognition test consisted of the target, six new words (not used in the priming phase or the encoding phase), and one word (a *lure*) used in the priming phase but not in the encoding phase. Thus the increased recognition performance is entirely explainable by the number of times a subject was exposed to the stimuli. In the experiment the subjects encountered the primed target twice before the recognition test, the lure once before the test, and the new items not at all before the test. To establish unambiguously that target priming increases retrievability, other primed targets should have been presented as the distractors.

Subthreshold Priming Research and JOL

First Study: Subthreshold Target Priming

Lee, Narens, and Nelson (1993) applied the Jameson et al. (1990) subthreshold priming paradigm to the judgment of learning. The modified paradigm is shown in figure 4.4. After the determination of a subject's threshold time, the subject was presented with word pairs for study. Approximately 3–5 minutes after studying a word pair, the subject was presented a subthreshold prime for the pair, containing either the target word of the pair or a nonsense word, followed by a pattern mask. The subthreshold presentation time for the prime was 94% of that subject's established threshold time. Im-

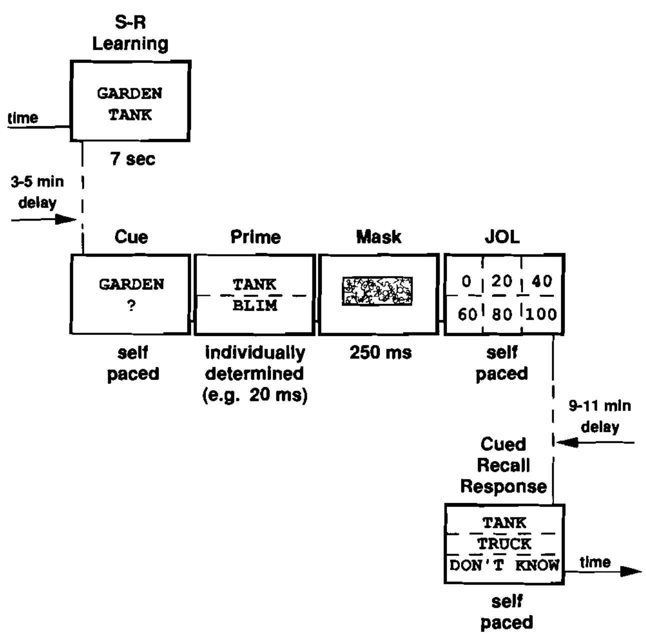

Figure 4.4
A typical sequence for a target priming and JOL experiment. S–R learning = "GARDEN–TANK." Prime = either target, "TANK," or a nonsense word, "BLIM." Response to the cue, "GARDEN," = either the correct answer, "TANK," an incorrect answer, e.g., "TRUCK," or a "DON'T KNOW" response. The 3–5 minute and the 9–11 minute intervals are filled by parts of other sequences.

mediately after the mask, each subject was presented the cue word of the pair and asked to make a prediction about the likelihood of correctly recalling the target word 10 minutes later on a final recall test. The prediction was recorded as the subject's JOL for the item. Nine to 11 minutes after making the prediction for the item a Final (Recall) Test for the item was administered to the subject in which the cue word of the item was presented, and the subject was asked to respond with the corresponding target word.

The 3–5 minute delay time between learning and JOL was selected because of theoretical considerations. Nelson and Dunlosky (1991) showed that subjects' JOL estimations at this time are extremely accurate predictors of final cued-recall performance (Goodman–

Kruskal gamma correlation = .9 or better). They called this highly accurate performance the *delayed JOL effect* to contrast it with the less accurate performance that results when the JOL estimations are made immediately after learning. We interpret part of their explanation for the delayed JOL effect as follows. The items that are cue-recallable at this delay time (i.e., items that would be recalled at this delay time if a cued recall test instead of a JOL were administered) are, except for very few items, the same items that are recalled on the final test. The high JOL accuracy results because of this and because the subject rates cue-recallable items higher than cue-nonrecallable items. (See Nelson & Dunlosky, 1992 for additional mechanisms and data for the delayed JOL effect. See also Spellman & Bjork, 1992.)

Lee et al. (1993) conjectured that with a 3–5 minute delay between learning and the time of JOL estimation, that subthreshold target priming could produce a transitory effect on recallability by changing some cue-nonrecallable items into cue-recallable items. They hypothesized that such changes of state of recallability could influence the JOL made just after priming. Because of the transitory nature of this kind of priming effect, the changed states would return to their original state of cue-nonrecallability before the later, final recall test. This suggests that subthreshold target priming could increase JOL ratings without increasing recall on the final test. Lee et al.'s (1993) experimental findings supported this hypothesis.

Lee et al. (1993) noted that JOLs for items nonrecalled on the final test had similarities to FOK judgments. FOK judgments are made for *nonrecalled* items from a prior recall test. Because of the Delayed JOL Effect, the *nonrecalled* items on the final test were, with very few exceptions, items that were *nonrecallable* when the JOLs for them were made. The JOLs for items recalled on the final test have a similar relationship to Confidence judgments.

Lee et al. (1993) found that the final recall for neutrally primed items was the same as for target primed items [$N = 46$; M(neutral) = .450, $SEM = .04$; M(target) = .431, $SEM = .04$; $t(45) = 0.922$, $p = .36$]. They also found that target priming increased JOL ratings for nonrecalled items on the final test,[4] but did not increase JOL ratings for recalled items on the final test [Wilcoxon tests: $Z = 2.346$, p = .01; $Z = 1.008$, $p = .16$; respectively]. Target priming did not increase

JOL ratings, although the trend was in that direction [Wilcoxon test: $Z = 1.219, p = .11$].

This result, that target priming increases JOL for nonrecallable final test items while producing no increase for recall on the final test, appears to contradict Jameson et al. (1990). However, Lee et al. (1993) provide a theory that explains both findings. The theory combines features of explanations offered by Nelson and Dunlosky for the delayed JOL Effect with those offered by Jameson et al. for increased recall due to subthreshold target priming.

To make the Lee et al. results more parallel with those of Jameson et al., call the JOLs for nonrecalled items on the final test *LFOK judgments* and JOLs for recalled items on the final test *LConfidence judgments* (figure 4.5). The empirical finding of the delayed JOL

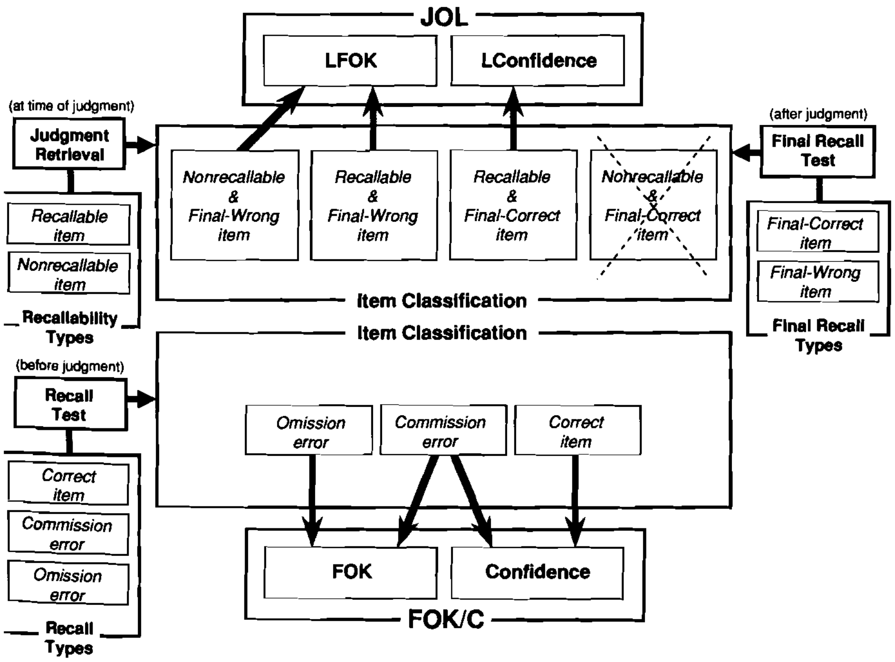

Figure 4.5
Similarities and differences between JOL and FOK/C judgments. For JOL, "Final-Wrong" items = commission and omission errors. "Nonrecallable & Final-Correct" items are ruled out by theoretical assumptions.

effect shows that almost all LConfidence judgments have higher ratings than almost all LFOK judgments. Application of the above explanation of delayed JOL effect to this situation then yields the following: Subjects, in making judgments of learning, rate recallable items (which with very few exceptions become recalled items on the final test) higher than nonrecallable items (which become nonrecalled items on the final test). In the Jameson et al. (1990) experiments, after recall all items were rated on a FOK/C scale according to their likelihood of being correctly answered on a multiple-choice test. On this common FOK/C scale, confidence judgments did not completely dominate FOK judgments, that is, many omission errors were rated higher than commission errors or correct items. (Otherwise, the increased recall due to target priming would have yielded a positive effect of target priming on the FOK/C ratings.)

The empirical evidence that LFOK has a different kind of ranking relationship to LConfidence than FOK has to confidence reflects, in our view, a difference inherent in the tasks presented to the subject. In accordance with the theoretical explanation of Jameson et al. (1990), this difference may not result from an increase in LFOK ratings due to monitoring of the information presented by the subthreshold target prime. As Lee et al. (1993) suggest, the effect of subthreshold target priming may be due entirely to the effect on memory retrieval strength, changing some LFOK items into LConfidence items. Then the difference in results of Lee et al. (1993) and Jameson et al. (1990) is more readily explainable. In the JOL task presented by Lee et al., the subject is predicting subsequent performance on a *cued-recall* test given several minutes later. In this situation, a rational strategy for the subject in estimating JOLs for items for which he or she has no response is to rate them below those for which he or she has a response, even if the correctness of that response is greatly in doubt — the "if it can't be recalled now, it is not going to be recalled in 10 minutes" strategy. This strategy leads to LConfidence items being rated higher than LFOK items. If the study by Jameson et al. (1990) were altered so that the FOK/Confidence ratings were for a recall test to be given 1 minute later, then a similar rating strategy might be rational in that situation. However, for a subsequent *recognition test* it is not. For a subsequent recognition test, it is rational for subjects to rate items with strong FOK higher than items with low confidence, that is, to rate items for which they do not have an answer but have a strong FOK higher than items for which they have answers but great doubt about the answers' correctness. In this way the findings of Lee et al. are consistent with those obtained by Jameson et al. (1990).

Second Study: Subthreshold Cue and Target Priming

In a second study, Lee et al. (1993) compared the different effects on JOL of cue and target priming. The experimental design for this study was essentially the same as their previously discussed study with three important differences: (1) in the priming phase cue words as well as target and neutral words were primed; (2) the duration between the JOL estimation for an item and the Final Recall test for that item was shortened from 9–11 to 4–7 minutes; and (3) the final recall for some items occurred before other items were learned.

In this study Lee et al. showed the following priming results:

1. Target priming produced higher recall than neutral priming.
2. There was no difference between cue priming and neutral priming on recall [$N = 42$; M(neutral) = .391, $SEM = .04$; M(target) = .470, $SEM = .04$; M(cue) = .417, $SEM = .04$; $F(2, 82) = 6.22$, $p < .01$, $MS_e = 0.01$].
3. Target priming yielded higher JOL ratings than either cue priming or neutral priming [Wilcoxon tests: $Z = 2.697$, $p = .004$, and $Z = 2.549$, $p = .01$, respectively].
4. Cue and neutral priming produced no difference in JOL ratings.

Note that the finding of Lee et al. (1993) described in the previous section that target priming produced higher JOL ratings than neutral priming is replicated in the current experiment.

The findings also showed that cue priming did not increase JOL with respect to neutral priming [Wilcoxon test: $Z = -0.525$, $p = .30$]. Other data of Lee et al. (1993) also showed that this was the case when the items were analyzed separately, based on type of final recall performance (correct/wrong). Cue priming did not increase JOL for either final recalled items or final nonrecalled items. In fact, the trends were in the other direction [Wilcoxon tests: $Z = -0.550$ and

$Z = -1.919$, respectively]. This latter finding runs counter to results of Reder (1987, 1988), Schwartz and Metcalfe (1992), and Schwartz (1992). However, because of the many differences in paradigms between studies we draw no conclusions about this.

Summary

The several studies described in the previous sections show that priming can influence the metacognitive judgments FOK, FOK/C, and JOL. It is natural to ask what aspects of the primed material are being monitored when making a given metacognitive judgment. Although the studies presented above are not rich enough to give a definitive answer to this question, they bear on two important aspects of it: (1) Is the information contained in the prime being monitored? (2) Is target retrievability or cue familiarity being monitored? We will now consider these two issues in the context of the presented findings.

In the Nelson et al. (1984) study, the subthreshold target prime — and consequently the information contained in it — was presented after the metacognitive FOK judgment, and therefore the information contained in the prime could not have been monitored by the FOK judgment. In the Jameson et al. (1990) study, subthreshold target priming increased recall but did not influence the metacognitive FOK/C judgment. Therefore there is no reason to expect that the information presented by the target prime was monitored in that study. In the Lee et al. (1993) study, subthreshold target priming had an effect on JOL estimations, but this effect was attributable to monitoring the state of the item, that is, monitoring whether or not the item was recallable, rather than monitoring the information contained in the target prime. In theory, the information contained in the target primes changed the states of some items from "nonrecallable" to "recallable" without the information contained in the primes or the changes in item states being monitored.

Schwartz and Metcalfe (1992), and Schwartz (1992) showed positive effects of cue priming on the metacognitive FOK judgment, and Reder (1987, 1988) showed a positive effect of cue priming on a related metacognitive judgment. These researchers consider that "familiarity" is a feature that is being monitored in making the relevant metacognitive judgments, and they concluded that the observed effects of priming on the judgments were due to cue priming increasing familiarity. However they provided no theory about (1) how cue priming increased familiarity, and (2) whether the information contained in the cue prime was being monitored as part of the metacognitive judgment. Metcalfe (1993) does provide an explicit theory of how cue familiarity is computed and monitored. According to Metcalfe's theory the information contained in the prime is being monitored.

The studies on cue priming discussed in this chapter provide evidence for the cue familiarity hypothesis for the metacognitive judgment FOK — that in making FOK judgments the familiarity or recognizability of the cue is assessed. No evidence that cue familiarity affects the metacognitive judgments JOL and LFOK was found by Lee et al. (1993). The study by Nelson et al. (1984) involving target priming provided indirect evidence for the target retrievability hypothesis by showing that FOK judgments are based on partial retrieval information about the target. Portions of studies by Schwartz and Metcalfe (1992) and Schwartz (1992) concerning the effect of target priming on FOK had methodological difficulties, and because of this, they were not good tests of the target retrievability hypothesis for FOK. Jameson et al. (1990) provided evidence against the target retrievability hypothesis for the metacognitive judgment of FOK/C. For Lee et al. (1993), results concerning the metacognitive judgments of JOL and LFOK are interpreted in a way that makes the target retrievability hypothesis untestable.

Conclusions

The empirical studies discussed in this chapter showed varied patterns of relationships between priming and metacognitive judgments, as summarized above. With occasional theoretical interpretations, the patterns boil down to the following: (1) For both supertheshold and subthreshold priming, target priming increased retrievability of targets but did not increase judgments of knowing or learning for those items whose targets were not retrievable at the time of judgment. (2) For supertheshold priming, cue priming increased judgments of knowing of items whose targets were not retrievable at the time of judgment, often without an increase in retrieval. (3) For subthreshold priming, cue priming did not increase JOLs.

Despite many empirical findings and some theorizing, there are still gaps in the discussed research. At the empirical level, two loose ends need to be resolved. First, a better paradigm is needed for testing the effect of superthreshold target priming on the FOK for items for which subjects attempted recall but failed. Second, the effects of subthreshold cue and target priming on the JOL needs to be examined under a wider range of contexts, for example, for rapid judgments like those used in Reder's "game show" paradigm (1987). At the theoretical level, our understanding of the issues and implications of the major concepts discussed in this chapter would be enhanced by additional mathematical and formal models.

Acknowledgments

This research was partially supported by National Institute of Mental Health Grant MH32205. We thank Nancy Alvarado, Janet Metcalfe, and Thomas O. Nelson for helpful comments.

Notes

1. Reminiscence is the subsequent correct recall of nonrecalled items without priming. Reminiscence needed to be taken into account because high FOK items are more likely to be recalled without priming than low FOK items (Gruenberg et al., 1973; Hart, 1967; Read & Bruce, 1982).

2. Nelson et al.'s (1984) results showed a correlation only between FOK and ease of identification.

3. Due to small variations in presentation times resulting from properties inherent in their equipment, Jameson et al. (1990) conservatively described their presentation times and method of priming as "near threshold" rather than "subthreshold."

4. In this instance the methodological pitfall discussed earlier is avoided because recall was not significantly influenced by target priming and more neutrally primed items were recalled than target primed items.