Mem Cogn (2013) 41:897–903
DOI 10.3758/s13421-013-0307-8

Easily perceived, easily remembered? Perceptual interference produces a double dissociation between metamemory and memory performance

Miri Besken · Neil W. Mulligan

Published online: 5 March 2013

Abstract A recent candidate for explaining metamemory judgments is the perceptual fluency hypothesis, which proposes that easily perceived items are predicted to be remembered better, regardless of actual memory performance (Rhodes & Castel Journal of Experimental Psychology: General 137:615–625, 2008). In two experiments, we used the perceptual interference manipulation to test this hypothesis. In Experiment 1, participants were presented with intact and backward-masked words during encoding, followed by a metamemory prediction (a list-wide judgment of learning, JOL) and then a free recall test. Participants predicted that intact words would be better recalled, despite better actual memory for words in the perceptual interference condition, yielding a crossed double dissociation between predicted and actual memory performance. In Experiment 2, JOLs were made after each study word. Item-by-item JOLs were likewise higher for intact than for backward-masked words, despite similar actual memory performance for both types of words. The results are consistent with the perceptual fluency hypothesis of metamemory and are discussed in terms of experience-based and theory-based metamemory judgments.

Keywords Perceptual interference · Metamemory · Perceptual fluency

Metamemory refers to beliefs and judgments about how memory operates. These beliefs and judgments are important because they guide choices about how we deploy cognitive resources. For example, if a student believes that some facts are likely to be remembered for a test but others are not, he or she may allocate more study time to the latter. If an instructor perceives some material to be harder to learn, more class time may be spent on that material, as compared with material thought to be easier. If metamemory does not accurately predict memory performance, however, the allocation of cognitive resources may be far from optimal. One potentially misleading heuristic for metamemory is based on perceptual fluency. The present study shows that a manipulation of perceptual fluency, the perceptual interference manipulation, produces a crossed double dissociation between metamemory and actual memory performance: Perceptual interference reduces judgments of learning (JOLs) while enhancing recall, as compared with a perceptually intact control condition.

Research on metamemory has attempted to delineate the heuristics and cues that guide metamemory predictions and has sometimes found that these heuristics are not aligned with actual memory performance (e.g., Koriat, 1997; Koriat & Bjork, 2005; Kornell, Rhodes, Castel, & Tauber, 2011). A recent candidate is perceptual fluency, the ease with which a stimulus can be perceived during memory encoding. It has been known for quite some time that manipulations of perceptual fluency during retrieval can produce memory illusions—for example, the belief that a more easily perceived test item is likely to be an old item, a form of memory misattribution in which present perceptual ease is mistakenly assumed to indicate the stimulus's prior presentation (e.g., Jacoby & Whitehouse, 1989). More recently, it has been suggested that perceptual fluency during encoding may induce a complementary illusion, the illusion that a more easily perceived item is more likely to be remembered on a later test, despite the fact that ease of processing during encoding does not typically enhance later memory. To examine this possibility, Rhodes and Castel (2008) varied the font size for study words under the assumption that a larger

M. Besken (✉) · N. W. Mulligan
Department of Psychology, University of North Carolina at Chapel Hill, Davie Hall CB#3270,
Chapel Hill, NC 27599-3270, USA
e-mail: mbesken@gmail.com

font would make reading easier (i.e., perception more fluent) than would a small font. The large words were rated as more likely to be recalled on a later memory test but, in fact, led to the same level of recall as words in small font (a finding replicated in subsequent research; Kornell et al., 2011; McDonough & Gallo, 2012; Miele, Finn, & Molden, 2011[1]). Rhodes and Castel (2008) concluded that perceptual fluency during encoding produced an illusion in metamemory, inducing a belief that the item would be easier to recall later on the basis of its current ease of perception. Rhodes and Castel (2009) provided a similar demonstration in the auditory modality, in which study words played at a louder or softer volume (assumed to affect perceptual fluency) significantly affected metamemory judgments but not actual recall.

Although these results are suggestive of a role for perceptual fluency in metamemory, they are limited in two ways. First, although it is plausible that font size impacted perceptual fluency, it is not clear that font size in the range manipulated (18–48 points) did so, since no direct measure of perceptual fluency (e.g., reading time) was used.[2] To be more certain that perceptual fluency impacts metamemory, an encoding manipulation with known effects on perception is needed.

Second, the foregoing results represent single dissociations, in which a purported manipulation of perceptual fluency during encoding impacted the metamemory measure but not recall. Although this data pattern is consistent with the notion that different processes underlie the two measures (i.e., that perceptual fluency at encoding affects metamemory but other processes affect actual memory performance), it does not compel this conclusion. Single dissociations may simply reflect differential sensitivity to a common underlying process (Berry, Shanks, & Henson, 2008; Newell & Dunn, 2008). Furthermore, strong reliance on the single dissociations reported by Rhodes and Castel (2008, 2009) requires that the perceptual fluency manipulation (large vs. small font; loud vs. soft word volume) really does not impact memory performance. That is, the null result on the recall measure needs to be trustworthy. Interestingly, the manipulations often produced small (nonsignificant) effects on recall in the same direction as the effect on metamemory (e.g., loud > soft). Furthermore, Foster and Sahakyan (2012) reported that under some conditions, loud words actually produce greater recall than do soft words.[3] In a similar vein, Yue, Castel, and Bjork (2013) investigated the effects of blurring words on memory and metamemory. When participants were presented with mixed lists of blurred and clear words, higher JOLs were assigned to the more perceptually fluent, clear words. Actual memory performance sometimes mimicked the metamemory ratings, with clearer words revealing better (Experiments 1a and 2a), or equivalent (Experiments 1b, 2b, and 3) memory, as compared with blurred words. This is another demonstration that single dissociations do not warrant sufficient evidence for the separability of metamemory measures from memory measures. Consequently, the single dissociations may not provide unambiguous support for the perceptual fluency hypothesis. More compelling evidence would be derived from a crossed double dissociation in which a single encoding variable produces opposite effects on metamemory and actual memory performance. Such a pattern is far more theoretically constraining than single dissociations (Berry et al., 2008; Dunn & Kirsner, 1988), is more difficult to attribute to a single underlying process, and is predicted by a consideration of the effect of perceptual interference on memory.

Under some conditions, interfering with word perception can enhance later memory. Specifically, in the perceptual interference manipulation, study words are presented either in an intact condition, in which a word is easily read, or in a perceptual interference condition, in which the word is presented very briefly (e.g., 100 ms) and then backward masked. The perceptual interference condition typically leads to better recall and recognition (Mulligan & Lozito, 2004; Nairne, 1988). Furthermore, the effect arises during word perception; if the mask is delayed until after word perception is complete (e.g., a mask at 266 ms), the effect no longer occurs. Theoretically, the effect arises as a result of higher compensatory processes that were not completed during word perception. Finally, and critically for present purposes, the perceptual interference condition reduces perceptual fluency as measured by both identification rates and identification latencies (e.g., Hirshman, Trembath, & Mulligan, 1994). This makes the perceptual interference manipulation an ideal candidate for examining the perceptual fluency hypothesis. The manipulation has a known negative effect on

[1] The illusion disappears with individuals with an incremental orientation toward intelligence.

[2] An indirect measure of perceptual fluency, ease-of-reading ratings, were reported to be higher for large than for small font words. However, this subjective rating may reflect a belief about the likelihood of large words being easier to read or an experimenter-demand effect, given the salience of the font manipulation.

[3] It is important to note that these deviations occurred under directed-forgetting instructions, with Foster and Sahakyan (2012) suggesting that participants preferentially rehearsed to-be-remembered items that were loud. Thus, the difference in memory performance may reflect a strategy shift rather than any inherent differences in the memorability of the items. Still, participants' strategy to rehearse the loud words under certain conditions might be indicative of the vulnerability of the manipulation to demand characteristics.

perceptual fluency during encoding (as assessed by direct measures of identification accuracy and latency) and has a positive effect on actual memory performance. Thus, perceptual interference should produce lower predicted memory performance, according to the perceptual fluency hypothesis, while enhancing actual memory performance. That is, the perceptual interference effect should produce a crossed double dissociation between metamemory and actual memory performance.

Experiment 1

Method

Participants

Seventeen undergraduates from the University of North Carolina participated in exchange for course credit.

Design and materials

Encoding condition (intact vs. interference) was manipulated within subjects. The study list consisted of 36 critical words, all common nouns of four to five letters, with 4 additional words at the beginning and end of the list as primacy and recency buffers. Intact and interference trials were randomly intermixed. Two versions of the list were constructed, counterbalancing words across the two encoding conditions.

Procedure

Participants were tested individually in a well-lit room, seated approximately 100 cm away from the computer screen. The experiment consisted of a study, a distraction, and a test phase. During the study phase, each trial began with a fixation point (a plus sign) for 500 ms, followed by a word in Times New Roman 9-point font. In the intact condition, the word was presented for 2,500 ms. In the perceptual interference condition, the word was presented for 83 ms, replaced by a row of Xs for 2,417 ms. Participants were instructed to read the words aloud and try to remember the words for a later memory test. At the end of the study list, participants were asked to make predictions about the upcoming memory test separately for the intact and the perceptual interference words. They were told that the list contained a total of 44 words, half presented intact and half masked. They were prompted to type their prediction for how many words of each kind they would recall out of 22. The order of the two memory predictions was counterbalanced across participants.

Next, participants were given a 3-min distractor task of math problems. This was followed by the recall test, in which participants were asked to recall (and write down) as many of the words as possible. They were given 5 min for the test.

Results and discussion

For all analyses, the alpha level was set at .05. Participants must have identified at least 80 % of the study words in the perceptual interference to be included in the experiment, a criterion resulting in the replacement of 1 participant in the present experiment and no participants in the subsequent experiment. During the study phase, identification rates were quite high in the perceptual interference condition but still significantly lower than in the intact condition by a sign test (98 % vs. 100 %). This difference indicates that the perceptual interference manipulation made word perception more difficult (i.e., less fluent; also as was noted earlier, response times to identified words are also slower in the perceptual interference than in the intact condition; Hirshman et al., 1994). Although the high identification rates make it possible to analyze the data without conditionalizing on correct identification at study, analyses were carried out on data both conditionalized on correct study identification and unconditionalized. Because both analyses led to the same conclusions, only the unconditionalized data are reported for the memory recall performance.

Participants predicted that they would recall fewer of the perceptual interference words (M = 8.63, SD = 4.16) than of the intact words (M = 10.69, SD = 3.72), $t(15)$ = 2.98, p = .009, d = 1.07. However, on the memory test, participants actually recalled more words from the perceptual interference condition (M = 5.38, SD = 1.86) than from the intact condition (M = 3.81, SD = 1.80), $t(15)$ = 2.64, p = .018, d = 0.94 (see Fig. 1).

The results of the recall test replicate the standard perceptual interference effect, the finding that interfering with (but not preventing) perception can enhance memory for the words (Mulligan & Lozito, 2004). However, participants are clearly not aware of this benefit. Participants believe that the intact words will be better recalled, yielding a crossed double dissociation between a measure of metamemory and actual memory performance. This double dissociation is consistent with the idea that perceptual fluency during encoding is (incorrectly) taken as an indicator of which items will later be remembered. Of course, in the present case, perceptual fluency during encoding not only fails to help memory (cf. Rhodes & Castel, 2008), but

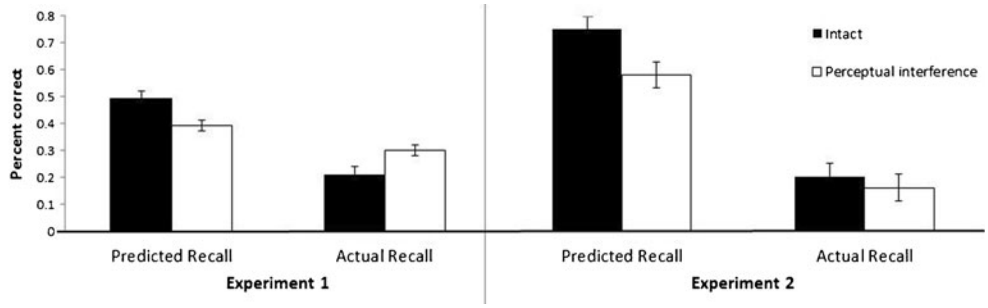

Fig. 1 Actual and predicted recall for Experiments 1 and 2. The raw scores are transformed into percentages in order to make the comparisons easier across experiments

also actually reduces memory performance, relative to a less fluent encoding condition.

Experiment 2

Lower JOLs for the perceptual interference condition provide support for the perceptual fluency hypothesis. However, prior research on JOLs indicates that these judgments may be based on two different information sources: experience-based processes and theory-based processes (Koriat, Bjork, Sheffer, & Bar, 2004). Experience-based processes refer to the subjective experience of the learner with an item or set of items. Thus, if the participant is having difficulty processing an item, this may be reflected in lower JOL ratings. The perceptual fluency hypothesis is an instance of an experience-based hypothesis about metamemory. Theory-based processes, on the other hand, are heuristics and beliefs about how memory operates. Contra the perceptual fluency hypothesis, lower JOLs in the perceptual interference condition might be indicative of a belief that participants hold that masked words are less memorable than intact words (see, e.g., Matvey, Dunlosky, & Guttentag, 2001, for another discussion of the analytic [theory-based]–nonanalytic [experience-based] distinction). Thus, it is natural to wonder whether the lower JOLs in the perceptual interference condition are a consequence of the fluency that participants experience or of a theoretical belief that the participants hold. In Experiment 1, we used a list-wide JOL at the end of the study phase. In Experiment 2, we used item-by-item JOLs. Koriat et al. (2004) showed that item-by-item JOLs are predominantly based on the subjective experience associated with the processing fluency, rather than on theory-based knowledge, whereas list-wide JOLs may be influenced by either type of process. The perceptual fluency hypothesis, of course, predicts that the less fluent perceptual interference condition will lead to lower item-by-item JOLs just as it did for list-wide JOLs. Alternatively, if the JOLs in Experiment 1 were solely theory based, this difference is unlikely to hold for the item-by-item JOLs of Experiment 2.

For the preceding reasons, Experiment 2 used item-by-item JOLs. However, it should be noted that the normal effect of perceptual interference on memory is not likely to occur under these condition. Research on a related phenomenon, the generation effect, shows this. If a JOL is made after each word, the typical generation effect (greater memory for generated than for read words) is not found (Begg, Vinski, Frankovich, & Holgate, 1991; Matvey et al., 2001). Two reasons are proposed in the literature for this. First, item-by-item JOLs might induce deeper, semantic encoding for all the items, overshadowing the typical effect of generation on memory (Matvey et al., 2001). Second, item-by-item JOLs might divert attention away from the items themselves toward the ratings and cause disruptions in the processing of the words themselves (Son & Metcalfe, 2005). Regardless of the correct explanation, the same empirical result is expected with the perceptual interference manipulation in the present experiment. The primary goal, however, is to determine whether lower JOLs for the perceptual interference condition persist when measured immediately after each item, which would be suggestive of online difficulties associated with subjective experience, rather than theoretical beliefs about masked words.

Method

Sixteen undergraduate students from the University of North Carolina participated in the study in return for class credit. Experiment 2 was identical to Experiment 1, except that the memory predictions at the end of the study list were eliminated and replaced with item-by-item JOLs. Specifically, participants were told that after each study word, they would rate their confidence that they would recall the word on the upcoming memory test on a scale from 0 to 100, with 0 indicating *no confidence at all* and 100 indicating *very high confidence*. The study trials proceeded as in Experiment 1. However, at the end of the trial, “Confidence (0–100)” was displayed on the screen. The participant typed in a response and pressed “Enter,” initiating the next trial.

Results and discussion

During the study phase, word identification was quite high in the perceptual interference condition but still significantly lower than in the intact condition by a sign test (96 % vs.

100 %). For each participant, an average JOL rating for the intact and perceptual interference trials was computed. For JOLs, only the analyses conditionalized on correct study identification are reported, because participants' lower JOL ratings for unidentified words in the perceptual interference trials might artificially decrease the average JOLs for the perceptual interference condition (although it should be noted that the results for JOLs also exhibit the same pattern of significance whether conditionalized on study identification or not).

JOL ratings were significantly higher for intact words (M = 75.03, SD = 19.83) than for words in the perceptual interference condition (M = 57.94, SD = 23.71), $t(15)$ = 3.65, p = .002, d = 1.31. On the recall test, the number of words remembered in the intact condition (M = 3.69, SD = 1.88) and perceptual interference condition (M = 2.94, SD = 1.00) did not significantly differ, $t(15)$ = 1.36, p = .194 (see Fig. 1). Given that this critical memory outcome is a null result, a consideration of power is in order. The results of Experiment 1 show that the perceptual interference manipulation produces an effect size of d = 0.94 for recall. The power of the present analysis to detect an effect of that size (n = 16, α = .05, one-tailed) is 0.83.

The relationship between fluency, JOLs, and recall also was examined by calculating the Goodman–Kruskal gamma correlations for each participant (Nelson, 1984). If perceptual fluency is informative of JOLs such that higher JOLs are given to intact (thus more fluent) items in the calculation, a positive correlation should exist between experimental condition and JOL, meaning that positive correlations entail higher JOLs for fluent items (Rhodes & Castel, 2008, 2009). The results showed that whereas the mean correlation between experimental condition and JOL (γ = .53, SD = .39) differed reliably from zero, $t(15)$ = 5.45, p < .001, d = 1.36, the mean correlation between experimental condition and recall (γ = .12, SD = .42) did not differ from zero, $t(15)$ = 1.14, p = .27.

In sum, the results of the JOL scores are again consistent with the perceptual fluency hypothesis: The perceptual interference condition produced lower JOLs than the more fluent, intact condition. This indicates that whether the prediction is taken at the end of the entire study phase (Experiment 1) or after each item is presented (Experiment 2), the less fluent items are predicted to be less well remembered.

With regard to actual memory performance, however, there was no difference between the two conditions. As was expected, requiring item-by-item JOLs eliminated the usual perceptual interference effect in free recall, just as occurs with the generation manipulation (Begg et al., 1991; Matvey et al., 2001). Even though the sample consists of 16 participants, the post hoc power analysis suggests that the sample size is reasonable to obtain a significant difference between the two conditions. The null memory results might have two potential causes. First, requiring item-by-item JOLs might have induced deeper encoding for the intact items, increasing their memorability (Matvey et al., 2001). The second potential explanation is that item-by-item JOLs might have diverted the attention away from the processing of the words themselves and may have caused participants to focus on the JOL ratings. The findings seem to favor the second explanation, because the recall rates decreased specifically for the perceptual interference items, as compared with Experiment 1. In the present case, the presentation of JOLs after each trial might have hindered the higher compensatory processes that would have occurred otherwise for the perceptual interference items (Hirshman et al., 1994). In either case, it is not uncommon for item-by-item JOLs to eliminate memory differences between conditions (Begg et al., 1991; Matvey et al., 2001).

General discussion

The results of two experiments indicate that the perceptual interference manipulation reduced predicted memory performance. This occurred whether the predictions were made on a trial-by-trial basis or at the end of the entire study list. This result is consistent with the perceptual fluency hypothesis, which argues that greater perceptual fluency during encoding is taken as an indicator of future memorability. The present demonstration is valuable because it clarifies earlier research in two important ways. First, the perceptual interference manipulation is known to affect perceptual fluency as assessed with direct measures like naming latency (Hirshman et al., 1994) or naming accuracy (as shown in the present experiment, as well as earlier research). In the present case, we can be more certain that the manipulation really affects perceptual fluency. Second, the perceptual interference manipulation produces a double dissociation between measures of metamemory and actual memory performance: Perceptual interference reduces metamemory but typically enhances actual memory performance. Such a crossed double dissociation provides stronger evidence for the perceptual fluency hypothesis than do single dissociations. That is, the perceptual fluency hypothesis argues that perceptual ease at encoding can affect metamemorial judgments but does not influence later memory performance. A crossed double dissociation provides clearer evidence that the measures of metamemory and memory are undergirded by different processes. Previous research has shown that the metamemory judgments are in the same direction as memory judgments, confounding the source of JOLs and recall. Unlike previous research, these two experiments clearly show that participants' predictions may be independent of their memory performance, providing unequivocal evidence about the separability of the effects of perceptual fluency on measures of memory and metamemory.

Even though JOLs can be guided by both analytic (beliefs, heuristics, theory-based) and nonanalytic (subjective fluency judgments, ease of processing, experience-based) processes, there are several reasons to conclude that lower JOLs in the perceptual interference condition are produced by subjective fluency in the present case. First, as was shown by Hirshman et al. (1994), the identification latencies for perceptual interference words were longer than those for intact words, indicative of perceptual difficulty in processing the masked words. So we know that the perceptual interference manipulation affects perceptual fluency. Second, Koriat et al. (2004) showed that item-by-item JOLs are predominantly based on the subjective experience associated with the processing fluency, rather than theory-based knowledge. In Experiment 2, the employment of item-by-item JOLs showed lower ratings in the perceptual interference condition, implying that these lower JOLs are mediated by the reduced perceptual fluency of this condition. Furthermore, the consistency of the JOL results of Experiments 1 and 2 indicates a similar basis of the JOL judgments across experiments.

Certainly, in some situations, the perceptual fluency hypothesis may be valid in predicting future memory performance, as in Yue et al. (2013). Some other research has also shown that fluency at encoding, as evidenced by self-paced study time[4] (Begg, Duft, Lalonde, Melnick, & Sanvito, 1989; Koriat, 2008), or fluency of retrieval from semantic memory (Serra & Dunlosky, 2005) might be valid predictors of subsequent memory performance under certain conditions. Yet fluency does not always affect memory in the same way. In certain cases, experiencing disfluency might challenge learners, leading to more effortful and deeper processing—thus enhancing memory. The present study of perceptual interference has clearly shown that a certain level of perceptual difficulty facilitates memory performance, unbeknownst to the participants.

Although the results support a role for perceptual fluency in metamemory, the effect of perceptual fluency is not always found, and additional research is required to determine when such effects are to be expected. For example, manipulations like smaller font size (Kornell et al., 2011; Miele et al., 2011; Rhodes & Castel, 2008), lower volume (Foster & Sahakyan, 2012; Rhodes & Castel, 2009), blurred words (Yue et al., 2013) produce lower metamemory judgments and lower or null effects on memory. On the contrary, in a recent study, Sungkhasettee, Friedman, and Castel (2011) had participants read inverted or upright words during encoding and found that JOLs did not differ between the two conditions, although inverted words were better remembered. Inverted words are expected to be perceived less fluently than upright text, so the perceptual fluency hypothesis leads to the expectation that the inverted words will produce lower JOLs (and indeed, produce the sort of crossed double dissociation found in the present Experiment 1). However, this was not the case. It is possible that the answer lies in the distinction between the experience-based and theory-based processes of JOLs. Certain manipulations of perceptual fluency (e.g., inverted text) might induce more analytic, theory-based judgments of learning that override nonanalytic bases of metamemory, rendering the subjective difficulty of reading inverted text ineffective in influencing JOLs. In contrast, other manipulations, such as perceptual interference, might induce feelings of subjective difficulty without triggering beliefs about how memory operates, producing the observed double dissociation between metamemory and memory.

Perhaps one way to distinguish how theoretical and experiential processes contribute to metamemory judgments is to use the learner–observer–judge method, introduced by Vesonder and Voss (1985) and used in evaluating retrieval fluency (Matvey et al., 2001) and conceptual difficulty, as evidenced by self-paced study time (Undorf & Erdfelder, 2011). Another method that might clarify the conflicting findings is to see whether different theories about intelligence would modify the findings of perceptual interference, as was valid with the font size manipulation (Miele et al., 2011). Clearly, more research is needed to determine whether the distinction between theoretical and experiential processes is germane to the conflicting findings regarding perceptual fluency and metamemory.

[4] It is important to note that ease of encoding, as evidenced by self-paced study time, is different than the concept of perceptual fluency. Increased self-paced study time might be indicative of conceptual difficulties experienced at encoding, unlike difficulties in perceiving the stimuli. In the present study, the study time has been kept equal in both intact and perceptual interference conditions.

References

Begg, I., Duft, S., Lalonde, P., Melnick, R., & Sanvito, J. (1989). Memory predictions are based on ease of processing. *Journal of Memory and Language, 28,* 610–632. doi:10.1016/0749-596X(89)90016-8

Begg, I., Vinski, E., Frankovich, L., & Holgate, B. (1991). Generating makes words memorable, but so does effective reading. *Memory & Cognition, 19,* 487–497. doi:10.3758/BF03199571

Berry, C. J., Shanks, D. R., & Henson, R. N. A. (2008). A single-system account of the relationship between priming, recognition, and fluency. *Journal of Experimental Psychology: Learning,* *Memory, and Cognition, 34,* 97–111. doi:10.1037/0278-7393.34.1.97

Dunn, J. C., & Kirsner, K. (1988). Discovering functionally independent mental processes: The principle of reversed association. *Psychological Review, 95,* 91–101. doi:10.1037/0033-295X.95.1.91

Foster, N. L., & Sahakyan, L. (2012). Metacognition influences item-method directed forgetting. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 38,* 1309–1324. doi:10.1037/a0027868

Hirshman, E., Trembath, D., & Mulligan, N. W. (1994). Theoretical implications of the mnemonic benefits of perceptual interference. *Journal of Experimental Psychology. Learning, Memory, and Cognition, 20,* 608–620. doi:10.1037/0278-7393.20.3.608

Jacoby, L. L., & Whitehouse, K. (1989). An illusion of memory: False recognition influenced by unconscious perception. *Journal of Experimental Psychology. General, 118,* 126–135. doi:10.1037/0096-3445.118.2.126

Koriat, A. (1997). Monitoring one's own knowledge during study: A cue-utilization approach to judgments of learning. *Journal of Experimental Psychology. General, 126,* 349–370. doi:10.1037/0096-3445.126.4.349

Koriat, A. (2008). Easy comes, easy goes? The link between learning and remembering and its exploitation in metacognition. *Memory & Cognition, 36,* 416–428. doi:10.3758/MC.36.2.416

Koriat, A., & Bjork, R. A. (2005). Illusions of competence in monitoring one's knowledge during study. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31,* 187–194. doi:10.1037/0278-7393.31.2.187

Koriat, A., Bjork, R. A., Sheffer, L., & Bar, S. K. (2004). Predicting one's own forgetting: The role of experience-based and theory-based processes. *Journal of Experimental Psychology. General, 133,* 643–656. doi:10.1037/0096-3445.133.4.643

Kornell, N., Rhodes, M. G., Castel, A. D., & Tauber, S. K. (2011). The ease-of-processing heuristic and the stability bias: Dissociating memory, memory beliefs, and memory judgments. *Psychological Science, 22,* 787–794. doi:10.1177/0956797611407929

Matvey, G., Dunlosky, J., & Guttentag, R. (2001). Fluency of retrieval at study affects judgments of learning (JOLs): An analytic or nonanalytic basis for JOLs? *Memory & Cognition, 29,* 222–233. doi:10.3758/BF03194916

McDonough, I. M., & Gallo, D. A. (2012). Illusory expectations can affect retrieval monitoring accuracy. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 38,* 391–404. doi:10.1037/a0025548

Miele, D., Finn, B., & Molden, D. (2011). Does easily learned mean easily remembered? It depends on your beliefs about intelligence. *Psychological Science, 22,* 320–324. doi:10.1177/0956797610397954

Mulligan, N. W., & Lozito, J. P. (2004). Self-generation and memory. In B. H. Ross (Ed.), *Psychology of learning and motivation* (pp. 175–214). San Diego: Elsevier Academic Press.

Nairne, J. (1988). The mnemonic value of perceptual identification. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 14,* 248–255. doi:10.1037//0278-7393.14.2.248

Nelson, T. O. (1984). A comparison of current measures of the accuracy of feeling-of-knowing predictions. *Psychological Bulletin, 95,* 109–133. doi:10.1037/0033-2909.95.1.109

Newell, B. R., & Dunn, J. C. (2008). Dimensions in data: Testing psychological models using state-trace analysis. *Trends in Cognitive Sciences, 12,* 285–290. doi:10.1016/j.tics.2008.04.009

Rhodes, M. G., & Castel, A. D. (2008). Memory predictions are influenced by perceptual information: Evidence for metacognitive illusions. *Journal of Experimental Psychology. General, 137,* 615–625. doi:10.1037/a0013684

Rhodes, M. G., & Castel, A. D. (2009). Metacognitive illusions for auditory information: Effects on monitoring and control. *Psychonomic Bulletin & Review, 16,* 550–554. doi:10.3758/PBR.16.3.550

Serra, M. J., & Dunlosky, J. (2005). Does retrieval fluency contribute to the underconfidence with practice effect? *Journal of Experimental Psychology: Learning, Memory, and Cognition, 31,* 1258–1266. doi:10.1037/0278-7393.31.6.1258

Son, L., & Metcalfe, J. (2005). Judgments of learning: Evidence for a two stage process. *Memory & Cognition, 33,* 1116–1129. doi:10.3758/BF03193217

Sungkhasettee, V. W., Friedman, M. C., & Castel, A. D. (2011). Memory and metamemory for inverted words: Illusions of competency and desirable difficulties. *Psychonomic Bulletin & Review, 18,* 973–978. doi:10.3758/s13423-011-0114-9

Undorf, M., & Erdfelder, E. (2011). Judgments of learning reflect encoding fluency: Conclusive evidence for the ease-of-processing hypothesis. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 37,* 1264–1269. doi:10.1037/a0023719

Vesonder, G. T., & Voss, J. F. (1985). On the ability to predict one's own responses while learning. *Journal of Memory and Language, 24,* 363–376. doi:10.1016/0749-596X(85)90034-8

Yue, C. L., Castel, A. D., & Bjork, R. A. (2013). When disfluency is—and is not—a desirable difficulty: The influence of typeface clarity on metacognitive judgments and memory. *Memory & Cognition, 41,* 229–241. doi:10.3758/s13421-012-0255-8