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On the Status of Unconscious Memory: Merikle and Reingold (1991) Revisited

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Four experiments are reported that reevaluate P. M. Merikle and E. M. Reingold's (1991) demonstration of unconscious memory: the greater sensitivity to familiarity (repetition) of an indirect (implicit) memory task than of a comparable direct (explicit) task. At study, participants named the cued member of a pair of visually presented words. At test, new and uncued study words were presented against a background mask. Participants judged whether each word was old or new (direct task) or whether the contrast between the word and the background was high or low (indirect task). Contrary to the original findings, the sensitivity of the indirect task to familiarity never exceeded that of the direct task. These findings pose a challenge to a key pillar of evidence for unconscious influences of memory.

Keywords: unconscious memory, implicit, repetition priming, awareness, recognition

In attempting to demonstrate memory without awareness, researchers often compare performance on indirect (implicit) and direct (explicit) tests of memory. In a direct test of memory, such as recognition, the instructions make specific reference to a prior study episode and require participants to discriminate between previously presented items and new items. The instructions for indirect tests of memory (e.g., perceptual identification; Jacoby & Dallas, 1981), however, make no reference to the prior study episode; instead, memory is typically inferred from a facilitation in the processing of an item (e.g., an increase in speed or accuracy in identifying an item). When this facilitation is due to prior exposure to that item, this phenomenon is referred to as *repetition priming*. Despite a wealth of research comparing performance on these two types of tasks (for a review, see, e.g., Roediger & McDermott, 1993), the evidence is scarce, particularly in normal adults, regarding the extent to which repetition priming can be shown in the absence of awareness (see Butler & Berry, 2001).

One approach to demonstrating memory without awareness is to aim to obtain significant repetition priming in an indirect task and null sensitivity on a direct memory task (e.g., chance recognition performance). From a dissociation of this sort, it could be argued that the repetition priming reflects a form of memory of which participants were not aware because if they were, then they would have used it in the direct test in which the motivation to do so was stronger (see Schacter, Bowers, & Booker, 1989). However, as others have noted, interpretation of such dissociation is not without its problems. For example, to claim that null awareness has been shown, one must assume that the purported direct test of memory exhaustively indexes all of the memory available to awareness, a difficult, if not impossible criterion to prove (see, e.g., Merikle & Reingold, 1990; Shanks & St. John, 1994). Another problem is that comparisons are frequently made between direct and indirect tasks with different characteristics: For example, the tasks may differ in such things as the retrieval cues provided at test, the response metric on which performance is measured, how reliable the tasks are, or the extent to which performance is affected by response bias. If any of these differences exist, then it could be argued that the observed dissociation is merely an artifact of the differences between the tasks themselves rather than differences in the forms of memory that they are purported to measure (Buchner & Wippich, 2000; Kinder & Shanks, 2001, 2003; Merikle & Reingold, 1991; Reingold, 2003).

In an attempt to circumvent many of these issues, Merikle and Reingold (1991) proposed that the logic of the relative sensitivity approach (Reingold & Merikle, 1988) could be used to provide unequivocal demonstrations of unconscious memory. In this approach, direct and indirect tasks are made as comparable as possible by matching them on all characteristics except task instructions; this has the advantage of constraining the number of possible interpretations of any observed dissociations. Merikle and Reingold argued that given a minimal a priori assumption—that "the sensitivity of a direct discrimination is assumed to be greater than or equal to the sensitivity of a comparable indirect discrimination to conscious, task relevant information" (Reingold & Merikle, 1988, p. 566)—unconscious processes are necessarily implicated whenever the sensitivity of an indirect task exceeds that of a comparable direct task, even if performance on the latter is above chance.

As an instantiation of this logic, Merikle and Reingold (1991) presented a pair of words, one above the other, for 500 ms on each study trial and required participants to read aloud the word that was cued with arrows. At test, a single word was presented on each trial against a mottled background mask that degraded the appearance of the word. Participants in the direct task judged whether the word had been presented in the study phase (old–new recognition judgments), and participants in the indirect task judged whether the

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contrast between the word and the background was high or low. Trials at test were arranged into three blocks consisting of an equal number of old and new words (either cued and new words in their Experiment 1 or uncued and new words in their Experiment 2). The key finding was that when uncued and new words were presented at test, the sensitivity of the indirect task in Blocks 1 and 2 was significantly greater than that of the direct task, which was at chance in these blocks. Given their a priori assumption, Merikle and Reingold interpreted this result as an "unequivocal demonstration of unconscious memory" (p. 231).

Our primary aim was to replicate this evidence for unconscious memory. This study has been cited over 100 times in the literature and has been referred to as an "existence proof" that repetition priming can be dissociated from awareness (e.g., Roediger & McDermott, 1993; Stadler & Roediger, 1998; Wippich, 1995); yet, to our knowledge, it has never been replicated. Merikle and Reingold also observed that, for uncued words, the sensitivity of the direct task increased across test blocks, whereas the sensitivity of the indirect task decreased. Recently, Erdelyi (2004) has argued that these block effects may have implications for the transitory nature of direct and indirect performance over time. Plainly, given the impact and potential implications of Merikle and Reingold's findings, their results demand replication.

We emphasize at the outset that we do not question the validity of Reingold and Merikle's relative sensitivity approach: If performance on indirect tests reflects, at least in part, information not available to awareness, then it should be possible to show greater sensitivity to previously exposed items in the indirect test than in the direct test, as Merikle & Reingold did. If, however, participants are aware of the information supporting greater-than-chance indirect test performance, then it follows that the sensitivity of the indirect task should not exceed that of a comparable direct test (see, e.g., Shanks & St. John, 1994).

Experiment 1

In Experiment 1, following Merikle and Reingold's method as closely as possible, we attempted to replicate their key finding that, for uncued words, the sensitivity of the contrast (indirect) task in Test Blocks 1 and 2 was greater than the sensitivity of a comparable recognition (direct) task (Merikle & Reingold, 1991, Experiment 2A). The contrast task can be shown to be a sensitive test of memory if judgments of visual contrast between a word and a background mask are affected by whether a word has been previously exposed. Jacoby, Allan, Collins, and Larwill (1988) showed that the intensity of background white noise is judged as lower when an old, rather than a new, item accompanies it; this is commonly regarded as reflecting the greater fluency that comes from reprocessing recently presented items (see also Gooding, Mayes, & Meudell, 1999). Applying this logic to the contrast task, an old word is assumed to be perceived more easily (or stand out more) than a new word against the background mask. Sensitivity to familiarity (prior exposure) can be shown in the contrast task if a greater proportion of old words are judged as being presented in high-contrast conditions than are new words.

Method

Participants. Psychology undergraduates ($N = 99$) from the University College London participated as part of a 1st-year laboratory class and were tested individually on computers in sound-dampened cubicles in all experiments. Their ages ranged from 18 to 40 years, with a mean of 19.5 years. Participants were allocated at random to either the contrast ($n = 53$) or the recognition ($n = 46$) tasks.

Materials and procedure. Following the same methods as Merikle and Reingold (1991; see Experiment 1), we randomly selected a pair of low-frequency words for each of the 60 study trials for each participant. The first 6 and last 6 trials acted as fillers; the stimuli from these trials were not presented at test. All stimuli were presented in white 26-point lowercase Arial font against a black background on a monitor with the screen resolution set to 1024 × 768 pixels.

Initially in the study phase, a white fixation dot, measuring 4 mm (0.31°)[1] in diameter, was presented at the center of a black background. Participants were told to initiate each trial when they were looking at the fixation dot by pressing the *Enter* key. After a trial was initiated, the fixation dot was replaced by a blank field for 200 ms. The target display was then presented for 500 ms and consisted of a pair of words, one presented 7 mm (0.50°) above the fixation dot and one 7 mm (0.50°) below. Each word was approximately 5–8 mm (0.38°–0.61°) high and was 30–36 mm (2.29°–2.75°) long. A white arrow 5 mm long (0.38°) was presented approximately 7 mm (0.50°) from each end of the cued word. The entire stimulus display measured approximately 34 mm (0.50°) vertically and 60 mm (4.57°) horizontally on the screen. Participants were required to read aloud the cued word; both accuracy and speed were emphasized in the instructions. A blank field 2,000 ms long followed the offset of the target display, after which the fixation dot reappeared to indicate that the participant should initiate the next trial. The cued word appeared an equal number of times above and below the fixation dot across study trials. No indication of the impending memory test was given.

At test, an uncued or new word was presented on each trial against a static rectangular mask. Trials were arranged into six 16-trial blocks with the constraint that each block contained an equal number of uncued, new, five-letter, and six-letter trials. Thus, there were 96 test trials in total, 48 uncued and 48 new word trials. In the mask, either 50% (high-contrast-condition mask) or 55% (low-contrast-condition mask) of the pixels were white.[2] Each mask measured approximately 45 mm (3.43°) horizontally and 10 mm (0.76°) vertically. For each participant, four high-contrast and four low-contrast masks were randomly generated. Each of the eight masks was used with one old and one new word in each block of 16 trials. Uncued and new words were presented equally as often in high- and low-contrast conditions. All participants were instructed to read the word aloud on each test trial and then make a decision concerning it.

Participants in the recognition task were instructed to press the *O* or *N* key to indicate whether they thought the word was "old" or "new." They were told that half of the words had been presented in the first stage but were words that they did not have to read aloud and that these words were therefore old; they were also told that the other half of the words had not been presented before in the experiment and were therefore new.

Participants in the contrast task were told that they would see a single word on each trial that would be presented against a background of visual

[1] The visual angle subtended by each stimulus dimension at a viewing distance of approximately 75 cm is provided within parentheses following each measurement.

[2] The low-contrast-condition mask density value differed slightly from that used by Merikle and Reingold (60%). The reason for this change was that the required contrast discrimination was deemed too easy with Merikle and Reingold's original mask densities. It is unlikely that any failure to replicate their results would be due to this change because our key findings held even when a constant mask density was used across trials in Experiments 2–4. Merikle and Reingold's pattern of results also held even when they used a constant mask density (Merikle & Reingold, 1991; Experiment 2B).

noise. They were told that half of the presentation conditions were high contrast and half were low contrast; their task was to judge the contrast. If a word appeared to stand out from the background, then the contrast was high and they were instructed to press the *H* key. If the word appeared to blend into the background, then the contrast was low and they were instructed to press the *L* key.

Before the target trials, all participants completed eight practice trials to familiarize themselves with the response buttons. In the recognition practice, the words "old" and "new" were presented four times each in an equal number of high- and low-contrast conditions; in the contrast practice, the word "word" was presented in an equal number of high- and low-contrast conditions.

All participants were told that the word would remain on the screen until they had pressed a key and that the required discrimination could be difficult to make. The instructions encouraged participants to do their best in making their judgments. No indication of test block transition was given, and no feedback was given as to the correctness of their response. Instructions between the two tasks were designed to be as similar as possible except for the required discrimination and references made to the study phase. The entire testing procedure took approximately 25 min. Participants were debriefed upon completion of the test phase.

Results and Discussion

An alpha level of .05 was used for all statistical tests. The assumption of sphericity was tested with Mauchly's *W* statistic. Huynh–Feldt's correction (Huynh & Feldt, 1976) was applied to the degrees of freedom when the assumption of sphericity was violated.

Sensitivity of the contrast and recognition tasks to familiarity. We analyzed the results in a fashion similar to that used by Merikle and Reingold (1991), first dividing each participant's 96 test trials into three blocks of 32 trials and then computing the sensitivity (A'; see J. G. Snodgrass & Corwin, 1988) of each task to familiarity (prior exposure) at each block.[3] For the recognition task, a hit was defined as responding "old" to an uncued word, and a false alarm was defined as responding "old" to a new word. For the contrast task, a hit was defined as responding "high" to an uncued word, and a false alarm was defined as responding "high" to a new word. Thus, in this first analysis, the data were collapsed across the contrast variable. The mean hit and false alarm rates to uncued words in both tasks are displayed in Table 1.

Figure 1 shows the mean sensitivity (A') of each task to uncued words at each test block and indicates that, in contrast to the findings of Merikle and Reingold (1991), the recognition task was more sensitive to familiarity than was the contrast task. A 2 × 3 mixed analysis of variance (ANOVA) with Task (recognition, contrast) and Block (Blocks 1, 2, 3) as factors revealed a significant main effect of Task, $F(1, 97) = 19.95$, $MSE = 0.02$, indicating that sensitivity to familiarity was indeed greater in the recognition task than in the contrast task, thus failing to replicate Merikle and Reingold's key evidence for unconscious influences of memory. In addition, performance did not reliably vary across Blocks, $F(2, 194) = 1.48$, $MSE = 0.02$, nor did the Task interact with the Test Block, $F(2, 194) = 1.09$, $MSE = 0.02$.

Further analysis confirmed that, for uncued words, the recognition task was sensitive, but the contrast task was not. Recognition performance was significantly greater than that expected by chance ($A' = .5$) at all three test blocks—Block 1, $M = .61$, $SEM = .02$, $t(45) = 5.15$; Block 2, $M = .56$, $SEM = .02$, $t(45) = 2.98$; Block 3, $M = .55$, $SEM = .02$, $t(45) = 2.68$—and also when collapsed across test blocks—overall $M = .58$, $SEM = .02$, $t(45) = 5.08$. Sensitivity in the contrast task, however, did not significantly differ from chance at any block or overall: Block 1, $M = .50$, $SEM = .02$, $t(52) = 0.07$; Block 2, $M = .50$, $SEM = .02$, $t(52) = 0.002$; Block 3, $M = .50$, $SEM = .02$, $t(52) = -0.25$; overall, $M = .50$, $SEM = .01$, $t(52) = 0.09$. Thus, whereas Merikle and Reingold (1991) found that, for uncued words, the contrast discrimination test was sensitive to familiarity, our results indicate that the contrast task was not sensitive to familiarity.

Sensitivity of the contrast and recognition tasks to contrast. Another way of analyzing the same set of data is to compute the sensitivity of each task to contrast (high or low contrast level). In this analysis, for the contrast task, a hit was defined as responding "high" to a high contrast level, and a false alarm was defined as responding "high" to a low contrast level. For the recognition task, a hit was defined as responding "old" to a word presented at high contrast, and a false-alarm was defined as responding "old" to a word presented at low contrast. Thus, in this analysis, the data are collapsed across the uncued–new manipulation.

Figure 2 shows the mean sensitivity (A') of each task to contrast and indicates that sensitivity to this dimension was much greater in the contrast than in the recognition task. In other words, when participants were instructed to judge the contrast level, they were able to do so, and their sensitivity to contrast was greater than that of participants responding indirectly to this dimension (i.e., in recognition). This was confirmed by a 2 × 3 mixed ANOVA with Task (recognition, contrast) and Block (Blocks 1, 2, 3) as factors, which revealed a main effect of Task, $F(1, 97) = 71.55$, $MSE = 0.04$. A significant Block effect was also obtained, $F(1.93, 187.00) = 3.14$, $MSE = 0.02$, indicating that performance changed over blocks; however, these two factors did not interact significantly, $F(1.93, 187.00) = 2.27$, $MSE = 0.02$.

The sensitivity of the contrast task to contrast significantly exceeded the chance level of performance at each test block and also overall: Block 1, $M = .70$, $SEM = .02$, $t(52) = 8.56$; Block 2, $M = .66$, $SEM = .02$, $t(52) = 6.64$; Block 3, $M = .70$, $SEM = .02$, $t(52) = 9.74$; overall, $M = .70$, $SEM = .02$, $t(52) = 10.15$. For the recognition task, sensitivity to contrast was significantly above chance in Test Block 3, $M = .54$, $SEM = .02$, $t(45) = 2.08$, suggesting that responding in this block was influenced by the ease with which a word was read against the background, independently of whether it had been previously exposed (cf. Whittlesea, 1993; see also Goldinger, Kleider, & Shelley, 1999); however, it was not significantly above chance in Block 1, Block 2, or overall: Block 1, $M = .47$, $SEM = .02$, $t(45) = -1.38$; Block 2, $M = .50$, $SEM = .02$, $t(45) = -0.19$; overall, $M = .50$, $SEM = 0.01$, $t(45) = 0.06$. Together, these results suggest that responding in the contrast task was influenced by the contrast between a word and the background and not by whether it was familiar (i.e., repeated).

[3] Where H = hits and FA = false alarms: For H ≥ FA, $A' = .5 + [(H - FA)(1 + H - FA)]/[4H(1 - FA)]$. For FA > H, $A' = .5 - [(FA - H)(1 + FA - H)]/[4FA(1 - H)]$. The hit and false-alarm rates were adjusted as suggested by J. G. Snodgrass and Corwin (1988) in order to avoid undefined values of the sensitivity measures. The data were also analyzed with Pr (= H − FA) and d' as alternative measures of discriminability, and the same qualitative pattern of results was found.

Table 1
Mean Hit and False Alarm Rates for the Recognition and Contrast Tasks

Experiment and condition	Block 1 Hits	Block 1 FA	Block 2 Hits	Block 2 FA	Block 3 Hits	Block 3 FA	Overall Hits	Overall FA
Experiment 1								
Recognition task								
M	.500	.367	.465	.389	.445	.379	.469	.373
SE	.021	.021	.024	.023	.027	.024	.019	.019
Contrast task								
M	.490	.489	.464	.459	.474	.477	.475	.474
SE	.023	.023	.025	.027	.022	.026	.020	.020
Experiment 2								
Contrast task–cued								
M	.506	.418	.521	.450	.521	.518	.516	.460
SE	.040	.038	.034	.024	.032	.037	.026	.022
Contrast task–uncued								
M	.532	.532	.524	.476	.471	.544	.509	.518
SE	.039	.043	.039	.031	.036	.042	.031	.028
Experiment 3								
Recognition task								
M	.505	.431	.417	.422	.466	.407	.461	.417
SE	.048	.051	.050	.041	.058	.052	.029	.031
Contrast task								
M	.529	.520	.510	.534	.505	.559	.515	.539
SE	.049	.046	.031	.042	.054	.046	.040	.041
Experiment 4								
100-ms study exposure								
Recognition								
M	.402	.402	.350	.395	.428	.337	.389	.373
SE	.036	.037	.033	.033	.043	.035	.032	.030
Contrast								
M	.484	.480	.451	.480	.454	.444	.461	.467
SE	.035	.040	.031	.039	.039	.037	.024	.029
500-ms study exposure								
Recognition								
M	.431	.353	.363	.363	.373	.270	.384	.321
SE	.064	.058	.062	.057	.065	.059	.060	.053
Contrast								
M	.402	.426	.495	.471	.480	.559	.457	.485
SE	.052	.050	.046	.042	.036	.023	.017	.018

Note. FA = false alarms.

The key result from this experiment was that the sensitivity of the direct task to familiarity was significantly greater than the sensitivity of the indirect task. Contrary to the findings of Merikle and Reingold (1991), the sensitivity of the direct task was greater than chance in Blocks 1 and 2, whereas the sensitivity of the indirect task was at chance in these blocks. The results therefore represent a complete failure to replicate their demonstration of unconscious memory. What was the reason for the null repetition priming effect in the contrast task? One possibility, as indicated from the previous analysis of each task's sensitivity to contrast, is that the difference in contrast levels may have interfered with any effect of prior word exposure on high or low responding. It is also possible that our contrast task is not a sensitive indirect test of memory. These two possibilities were addressed in the next experiment.

Experiment 2

In Experiment 2, we investigated repetition priming for cued and uncued study words in the contrast task. Unlike Experiment 1, every word in Experiment 2 was presented against a mask of the same density at test. If differences in the contrast levels prevent repetition priming, then a repetition priming effect may emerge for uncued words in Experiment 2. However, if contrast differences do not interfere with repetition priming, and instead the representation of uncued words formed at study is not sufficient to support repetition priming in this task, then we would expect to replicate our null effect from Experiment 1. We also aimed to show that the contrast task is a sensitive indirect test of memory by including a cued word condition (cf. Merikle & Reingold, 1991; Experiment 1). Repetition priming is deemed more likely for these words than for uncued words because more attention is paid to them at study (e.g., Crabb & Dark, 1999).

Method

There were three major differences from the general method of Experiment 1: (a) At test, participants made judgments about cued and new words (cued condition) or uncued and new words (uncued condition); (b) a fixed mask density (50%) was used on every test trial and was randomly generated for each trial; and (c) sensitivity was only measured in a contrast task.

The study phase procedure was the same as that used in Experiment 1 except that participants in all experiments were positioned approximately 100 cm from the screen at the start of the experiment, and naming responses were recorded so they could be later checked for accuracy. All other aspects of the method were the same as those used in Experiment 1.

Forty participants were randomly allocated to the uncued (n = 20) or cued (n = 20) word conditions. Their ages ranged from 18 to 27 years, with a mean of 20.1 years. Each participant in this and subsequent experiments was recruited from a University College London psychology department subject database, was tested in individual testing sessions, was paid £4 (approximately $7) for participation, and was told that the experiment concerned word perception. All reported normal or corrected-to-normal vision and reported English as their first language.

Results and Discussion

The results were analyzed in a fashion similar to that used in Experiment 1.[4] For every participant in the cued and uncued conditions, sensitivity (A') to familiarity was calculated at each test block of 32 trials, the means of which are displayed in Figure 3. A 2 × 3 mixed ANOVA with Cuing (uncued, cued) and Block (Blocks 1, 2, 3) as factors revealed a significant main effect of Cuing, $F(1, 38) = 5.04$, $MSE = 0.02$, indicating that sensitivity to familiarity was greater in the cued than in the uncued condition. Similar detrimental effects of manipulations of selective attention at encoding on repetition priming have been documented in the attention and repetition priming literature (Crabb & Dark, 1999; MacDonald & MacLeod, 1998; Mulligan, 2002; Phaf, Mul, & Wolters, 1994). There was also a significant main effect of Block, $F(2, 76) = 3.47$, $MSE = 0.02$, indicating that sensitivity changed across blocks; however, Block did not interact with Cuing, $F(2, 76) < 1$.

In the uncued condition, the sensitivity of the contrast task was not significantly greater than chance in Blocks 1 or 2 or overall: Block 1, $M = .50$, $SEM = .03$, $t(19) = -0.07$; Block 2, $M = .54$, $SEM = .03$, $t(19) = 1.32$; and overall, $M = .49$, $SEM = .02$, $t(19) = -0.53$. It was marginally significantly subchance in Block 3, $M = .44$, $SEM = .03$, $t(19) = -2.09$. In the cued condition, however, sensitivity was significantly greater than chance overall, $M = .55$, $SEM = .02$, $t(19) = 2.90$, but not at each block, Block 1, $M = .56$, $SEM = .03$, $t(19) = 1.94$; Block 2, $M = .56$, $SEM = .03$, $t(19) = 2.06$; and Block 3, $M = .50$, $SEM = .03$, $t(19) = 0.16$.

The null uncued repetition priming effect in this experiment was obtained despite a constant mask density being used on every test trial. This suggests that the null effect in Experiment 1 was also not due to interference from differences in the contrast level. The results also suggest that, as found by Merikle and Reingold, the contrast discrimination task is a sensitive indirect task: Indeed, the magnitude of cued word repetition priming obtained overall (M = .55) was comparable to that obtained by Merikle and Reingold (approx. M = .55 overall). This result supports the notion that prior exposure to words can influence judgments of perceptual contrast between a word and the background mask. However, more important, the results support the finding from Experiment 1 that, for uncued words, even when a constant mask density is used on each trial, the sensitivity of the contrast task does not significantly differ from chance and would therefore not exceed that of the comparable direct task.

The finding that recognition for uncued words was greater than chance overall in Experiment 1 but at chance in Blocks 1 and 2 of Merikle and Reingold's experiments raises the possibility that our participants may have been more motivated than Merikle and Reingold's in the recognition task. It could be argued that for true comparability with Merikle and Reingold, the sensitivity of the contrast task needs to be shown to be no greater than the sensitivity of the recognition task when recognition task sensitivity is at or closer to chance.

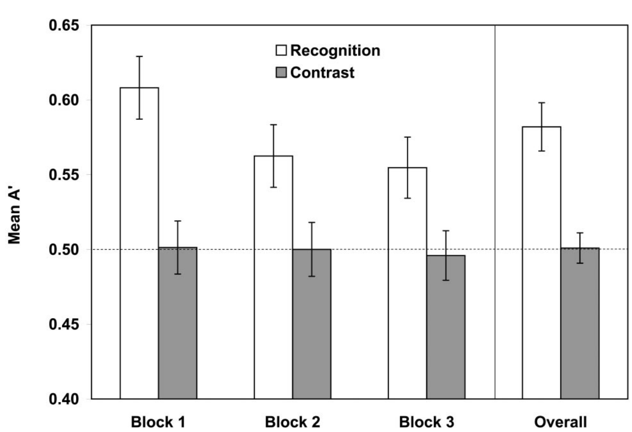

Figure 1. Mean sensitivity (A') of the contrast and recognition tasks to familiarity (old vs. new) at each test block and overall in Experiment 1. In the recognition task, participants decided whether each (uncued) study word was repeated, and in the contrast task, they decided whether the contrast between each word and the background was high or low. Data from the 96 test trials are presented both overall (right panel) and broken into 3 blocks (left panel). Bars indicate standard errors.

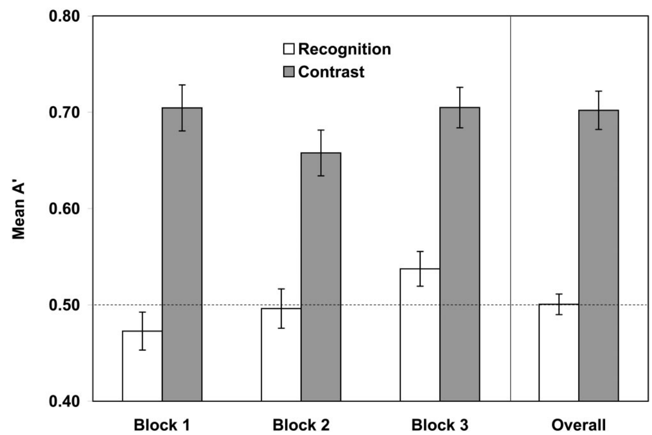

Figure 2. Mean sensitivity (A') of the contrast and recognition tasks to contrast (low vs. high) at each test block and overall in Experiment 1. Bars indicate standard errors.

[4] Study phase responses were checked after the experiment; because practically no errors (e.g., incorrectly naming the uncued word) were made in this and subsequent experiments, no further analysis was conducted upon the errors.

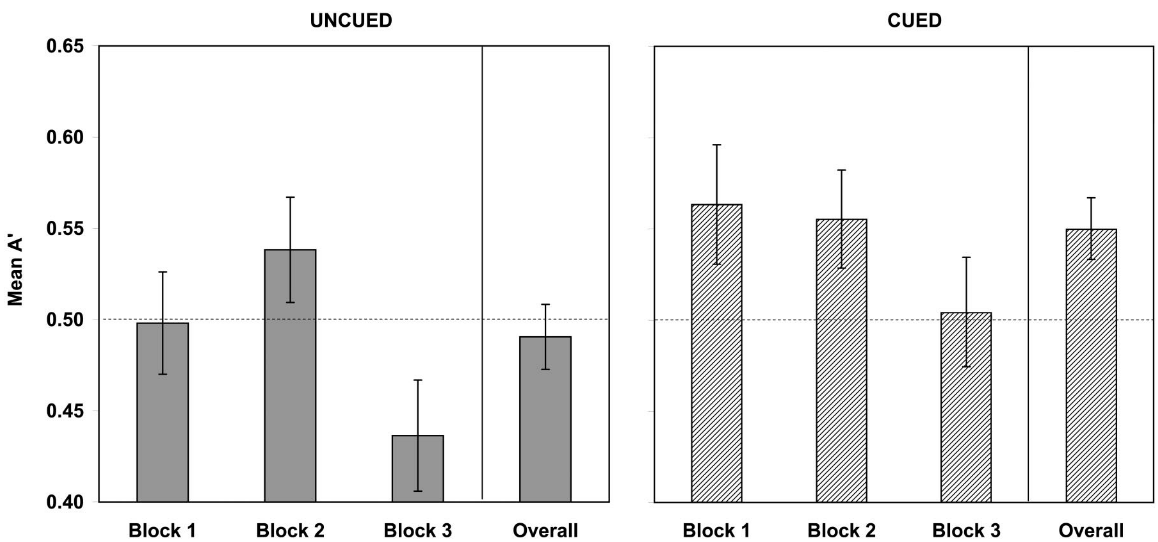

Figure 3. Mean sensitivity (A') of the contrast task to familiarity (old vs. new) at each test block and overall in Experiment 2. Left panel shows data for words that were uncued at study. Right panel shows data for words that were cued at study. Bars indicate standard errors.

Experiment 3

The aim of Experiment 3 was to reduce the sensitivity of the recognition task to chance for uncued words and then observe the size of repetition priming. In line with the view that attention is required for modification of long-term memory (see Cowan, 1995, for a review), reducing the study exposure duration should decrease the amount of attention paid to uncued words at encoding and therefore have a detrimental effect on recognition memory. Thus, in this experiment, cued and uncued words were presented for a shorter study exposure duration than the words were in Experiments 1 and 2, and performance was measured in both recognition and contrast tasks.

Method

All aspects of the design and method were the same as those for Experiment 1 with the following exceptions: (a) The exposure duration of the word pairs at study was reduced from 500 ms to 150 ms; (b) a fixed mask density (45%) was used on every test trial and was randomly generated for each trial; and (c) similar to Merikle and Reingold (1991; Experiment 2B), we set the frequency of the cued, uncued, and new word stimuli at 1 per million (Kucera & Francis, 1967).

We recruited 24 participants (12 contrast, 12 recognition). Their ages ranged from 18 to 22 years, with a mean of 22.0 years.

Results and Discussion

The mean sensitivity of each task to familiarity is displayed in Figure 4. The data from Experiment 3 were analyzed in a manner similar to that used in Experiment 1. A 2 $\times$ 3 mixed ANOVA with Task and Block as factors revealed a significant main effect of Task, $F(1, 22) = 5.85$, $MSE = 0.01$, indicating that for uncued words, the sensitivity of the direct task was significantly greater than that of the indirect task. No significant effect of Block, $F(2, 44) < 1$, or interaction between the factors, $F(2, 44) < 1$, was obtained.

Sensitivity to familiarity was significantly greater than chance in the recognition task overall, $M = .54$, $SEM = .01$, $t(11) = 2.82$, but not when considered at each block: Block 1, $M = .56$, $SEM = .04$, $t(11) = 1.62$; Block 2, $M = .49$, $SEM = .03$, $t(11) = -0.17$; Block 3, $M = .55$, $SEM = .03$, $t(11) = 1.55$. It is worth noting that decreasing the study exposure duration was effective in reducing recognition performance compared with the recognition group in Experiment 1. Recognition was significantly lower in this experiment, $t(39) = 1.85$ (one-tailed, correcting for unequal variances). Again, the contrast task was not found to be sensitive to familiarity either overall or at each block: overall, $M = .48$, $SEM = .02$, $t(11) = -0.97$; Block 1, $M = .51$, $SEM = .03$, $t(11) = 0.24$; Block 2, $M = .48$, $SEM = .03$, $t(11) = -0.65$; and Block 3, $M = .45$, $SEM = .04$, $t(11) = -1.21$. The greater variability in sensitivity across blocks in this experiment and in Experiment 2, compared

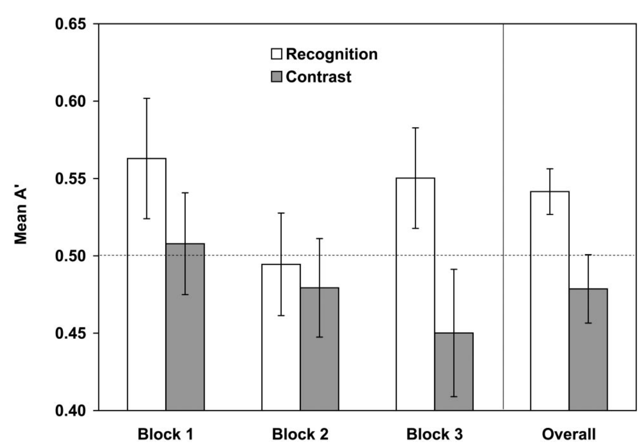

Figure 4. Mean sensitivity (A') of the contrast and recognition tasks to familiarity at each test block and overall in Experiment 3. Bars indicate standard errors.

with that in Experiment 1, although not reliable, can be attributed to the smaller number of participants in each experimental condition.

The results from Experiment 3 indicate that for uncued words, even when the study exposure is reduced to 150 ms, the overall sensitivity of the recognition task is still significantly greater than chance and significantly greater than that of the indirect task, which was at chance, thus replicating the results of Experiments 1 and 2.

Experiment 4

Despite the study manipulation we used in Experiment 3, recognition memory for uncued words remained above chance; thus, we used a more severe manipulation of attention at encoding in this experiment to minimize the likelihood of processing the uncued word to a sufficient depth necessary to support recognition performance. First, a red-lined box and red arrows cued the location of the cued word; second, this location was precued; third, the study exposure duration was reduced to 100 ms; and fourth, immediately after the presentation of the target display at study, the location of the uncued word was backward-masked. In addition, given that the pattern of our results thus far contradicts those of Merikle and Reingold, we also replicated our main findings using the original study exposure duration.

Method

In the 100-ms study exposure condition, the new sequence of events on each study trial was as follows: (a) A fixation dot was on screen until participants initiated the trial by pressing *Enter*; (b) the fixation dot was replaced by a blank field for 200 ms; (c) a red-lined box and two red arrows precued the location of the cued word for 150 ms; (d) the target display was presented for 100 ms, the cued word appearing within the red-lined box and arrows; and (e) on the offset of the target display and cue, the location of the uncued word was backward-masked for 500 ms with hash marks (########). All other aspects of the design and method of this condition were the same as those of Experiment 3. A second condition was added, which was identical to that used in Experiment 3, except that the study exposure duration was 500 ms.

There were 36 participants (18 contrast, 18 recognition) in the 100-ms study exposure duration condition and 24 participants (12 contrast, 12 recognition) in the 500-ms study exposure duration condition.

Results and Discussion

Study exposure duration of 100 ms. The sensitivity of each task to familiarity is shown in Figure 5. A 2 (contrast, recognition) × 3 (Block 1, 2, 3) mixed ANOVA revealed no main effect of Task, $F(1, 34) < 1$; Block, $F(2, 68) = 2.50$, $MSE = 0.02$; or interaction, $F(2, 68) = 1.35$, $MSE = 0.02$, indicating that sensitivity did not significantly differ in the recognition or contrast tasks overall, nor did sensitivity in each task vary reliably across blocks.

Sensitivity to familiarity in the contrast task did not significantly differ from chance at each block or overall: Block 1, $M = .50$, $SEM = .03$, $t(17) = 0.12$; Block 2, $M = .49$, $SEM = .03$), $t(17) = -0.43$; Block 3, $M = .51$, $SEM = .03$, $t(17) = 0.25$; and overall, $M = .50$, $SEM = .02$, $t(16) = 0.01$. Similarly, sensitivity in the recognition task was not significantly greater than chance in Block 1, Block 2, or overall: Block 1, $M = .49$, $SEM = .03$, $t(17) = -0.19$; Block 2, $M = .46$, $SEM = .03$, $t(17) = -1.27$; and overall, $M = .51$, $SEM = .02$, $t(17) = 0.67$, but was significantly greater than chance in Block 3, $M = .58$, $SEM = .03$; $t(17) = 2.67$. This apparent hypermnesia effect from Block 2 to Block 3 was confirmed by a significant paired-sample *t* test, $t(17) = 2.24$, and replicates Merikle and Reingold's finding of hypermnesia across these test blocks. This finding provides some support for Merikle and Reingold's suggestion that participants may have changed their strategy as trials progressed in the recognition phase.

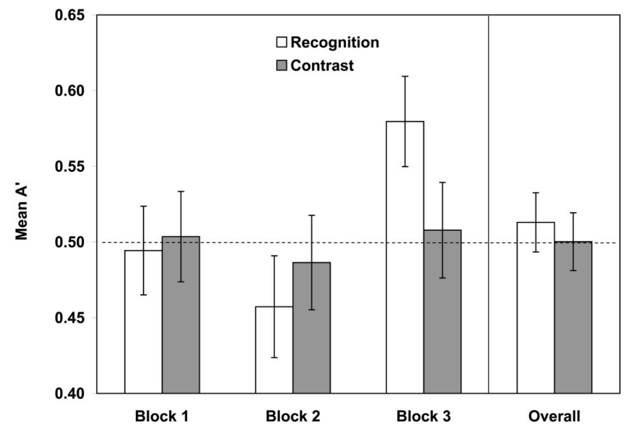

Figure 5. Mean sensitivity (A') of the contrast and recognition tasks to familiarity at each test block and overall in Experiment 4 (100-ms study exposure). Bars indicate standard errors.

The key finding, however, was that the stronger manipulation of attention used at encoding was successful in decreasing recognition memory to chance in Block 1, Block 2, and overall, thus achieving the desired comparability to Merikle and Reingold's recognition performance for uncued words. Despite this, no repetition priming was observed. We can conclude that when direct sensitivity is at chance, indirect sensitivity is similarly at chance.

Study exposure duration of 500 ms. The mean sensitivity of each task to uncued words is displayed in Figure 6. A 2 (contrast, recognition) × 3 (Blocks 1, 2, 3) mixed ANOVA revealed a significant effect of Task, $F(1, 22) = 6.95$, $SEM = 0.01$, indicating that the sensitivity of the direct task was greater than the sensitivity of the indirect task. No main effect of Block, $F(2, 44) < 1$, was found, nor did Task significantly interact with Block, $F(2, 44) = 2.69$, $MSE = 0.02$.

Sensitivity to familiarity in the recognition task was above chance overall, $M = .56$, $SEM = .02$, $t(11) = 2.44$, and in Block 3, $M = .60$, $SEM = .04$, $t(11) = 2.25$, but not in Blocks 1 or 2: Block 1, $M = .57$, $SEM = .04$, $t(11) = 1.73$; and Block 2, $M = .49$, $SEM = .04$, $t(11) = -0.30$. Sensitivity to familiarity in the contrast task did not differ from chance at each block or overall: Block 1, $M = .49$, $SEM = .04$, $t(11) = -0.14$; Block 2, $M = .52$, $SEM = .03$, $t(11) = 0.57$; Block 3, $M = .43$, $SEM = .03$, $t(11) = -1.95$; and overall, $M = .48$, $SEM = .02$, $t(11) = -1.34$. The results of this condition are in concordance with those of Experiments 1–3: For uncued words, the sensitivity of the recognition task was significantly greater than the sensitivity of the contrast task, which was at chance.

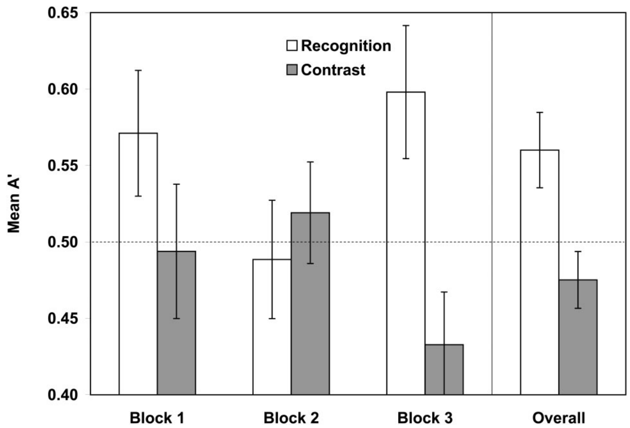

Figure 6. Mean sensitivity (A') of the contrast and recognition tasks to familiarity at each test block and overall in Experiment 4 (500-ms study exposure). Bars indicate standard errors.

Power of Experiments 1–4 to Obtain Repetition Priming of Uncued Words

Merikle and Reingold found that the priming effect for uncued words was largest in Block 1. Collapsing across our experiments, repetition priming was at chance in this block, M = .50, SEM = .01, $t(114)$ = 0.11. With the mean sensitivity (A' = .54) and standard deviation (.13) of Merikle and Reingold's contrast task in Block 1 (from Experiments 2A and 2B combined) as an estimate of the maximum repetition priming effect for uncued words, the power of the contrast task in our study to detect this effect, collapsed across all experiments, was .91 (one-tailed).

General Discussion

Our primary aim was to replicate key evidence for the existence of unconscious memory processes (Merikle & Reingold, 1991). According to the logic of the relative sensitivity approach (Reingold & Merikle, 1988), evidence for unconscious processes can be revealed whenever the sensitivity of an indirect task exceeds that of a comparable direct task. Despite adopting the same paradigm and procedures as Merikle and Reingold (1991), we found no evidence for unconscious influences of memory. Crucially, across four experiments, the sensitivity of the indirect task to uncued words was never greater than the sensitivity of the direct task. In contrast to Merikle and Reingold's findings, and despite ample statistical power, we found that contrast judgments were not sensitive to uncued study words when recognition was greater than chance in Experiments 1, 3, and 4 or when recognition was reduced to chance in Experiment 4. In Experiment 2, we showed that the contrast discrimination task is a sensitive indirect test of memory in that it was sensitive to the influence of cued study words (cf. Merikle & Reingold, 1991; Experiment 1).

Chance recognition is a difficult outcome to obtain, as indicated by our own and other researchers' findings. For example, not only did we obtain above-chance recognition in Experiments 1 and 4 (500-ms exposure duration), but we continued to do so in Experiment 3 with exposure durations vastly shorter than in those used in the Merikle and Reingold procedure. It was only in Experiment 4 (100-ms exposure duration), with extra procedures for ensuring that attention was withdrawn from the uncued words, that we eventually obtained chance recognition (in Blocks 1 and 2, at least). Similarly, Crabb and Dark (2003) showed that recognition memory persisted despite high perceptual loads and short exposure durations at encoding. For example, when four words were presented on every study trial, recognition memory for these words remained reliably greater than chance, even when the exposure duration was reduced from 600 ms to 200 ms. We note that without the chance-level recognition performance in Merikle and Reingold's study, their data would not show a repetition priming effect that was greater than the recognition memory effect and, hence, would not provide evidence for unconscious memory.

Numerous other studies corroborate our repetition priming results and have shown that when recognition is at or approaching chance, repetition priming effects similarly diminish or at least do not exceed recognition performance (e.g., Hawley & Johnson, 1991, Experiment 2; MacDonald & MacLeod, 1998; Moscovitch & Bentin, 1993; Mulligan, 2002). For example, in a similar encoding paradigm to the current experiments, MacDonald and MacLeod (1998, Experiment 3) cued one of two words on each study trial by presenting it in a specific color. For uncued words, they managed to obtain chance recognition memory but found no repetition priming in a rapid reading task. Indeed, as others have noted (e.g., Butler & Berry, 2001), few studies have demonstrated repetition priming in the absence of recognition memory.

This view appears to stand in contrast to reports of certain patients with amnesia who show repetition priming but perform at chance in recognition tests (e.g., patient E. P. in Hamann & Squire, 1997; Stark & Squire, 2000). However, this pattern is not common; amnesic patients typically perform above chance in recognition tests, making it difficult to discount the possibility that repetition priming effects reflect conscious influences of memory. Moreover, single-system models of priming and recognition reproduce the pattern of results obtained with amnesic patients without postulations of unconscious influences of memory (e.g., Kinder & Shanks, 2001, 2003).

The results do not challenge or undermine the logic of the relative sensitivity approach in demonstrating unconscious memory. Indeed, our results are inconsistent with mere exposure effect studies in which exposure to stimuli can increase liking judgments in the absence of recognition memory for those stimuli (e.g., Kunst-Wilson & Zajonc, 1980), and qualify, according to the logic of the relative sensitivity approach, as demonstrations of unconscious memory (see also Eich, 1984). However, this pattern has been replicated in some studies (e.g., Bonanno & Stillings, 1986; Seamon, Marsh, & Brody, 1984) but not in others (Fox & Burns, 1993; Newell & Shanks, 2006). Similarly, demonstrations of this pattern with nonaffect judgments are not ubiquitous. For example, early demonstrations of this effect with brightness and darkness judgments (Mandler, Nakamura, & van Zandt, 1987) have not since been replicated (Seamon, McKenna, & Binder, 1998). Whittlesea and Price (2001), however, were able to replicate this pattern when a global similarity task was used as the nonaffective task.

An important question is why our results differ so markedly from those of Merikle and Reingold. A study by Whittlesea and Price (2001) suggests that performance on direct and indirect tests of memory depends largely on the extent to which the instructions differentially hinder or facilitate the adoption of strategies that differ in the extent to which they allow probing of specific memory representations. By this alternative interpretation, it is the difference in strategy (i.e., an analytic or nonanalytic strategy) elicited by each task that mediates direct and indirect task performance (Whittlesea & Price, 2001; see also M. Snodgrass, 2004). It is possible that minor procedural differences between the Merikle and Reingold study and this one caused participants to adopt different strategies in Merikle and Reingold's, leading to the difference in findings. For example, if our instructions happened to encourage an analytic strategy at test (because, e.g., we encouraged participants to do their best in making their judgments), then this, as Whittlesea and Price showed, could have eliminated evidence for the influence of prior study in our indirect test, although it is less clear how a more analytic strategy would explain better recognition performance in our direct test relative to that of Merikle and Reingold. Other procedural differences may have contributed to the difference in our findings: The visual angles of our words in the study phase were slightly larger than Merikle and Reingold's, particularly in Experiment 1, which means that uncued words may have been more visible in our experiments, even when participants were fixating on the cued words. Unlike Merikle and Reingold, we did not require participants to use a chin rest in the study phase of our experiments, so it is possible that participants moved in the study phase and therefore the visual angle varied.

Last, the views presented here do not challenge or undermine demonstrations of dissociations between implicit and explicit memory tasks (e.g., Roediger & McDermott, 1993). Such dissociations clearly imply distinct forms of processing; however, one does not need to assume that unconscious memory processes are responsible for producing these dissociations. For example, transfer-appropriate processing explains many of these dissociations in terms of the differences between perceptual and conceptual processing (Roediger & McDermott, 1993) without saying anything about whether the participants are aware or unaware of the processes. Likewise, the wealth of evidence supporting Jacoby and colleagues' process dissociation procedure (e.g., Jacoby, Woloshyn, & Kelley, 1989) has been interpreted as evidence for memory without awareness (but see, e.g., Richardson-Klavehn, Gardiner, & Java, 1996, for an alternative interpretation). To identify unconscious memory processes, which are assumed in many theories of memory, we believe that it is necessary to use the type of approach used in this study of demonstrating repetition priming in the absence of awareness.

In conclusion, our results question a key pillar of evidence in support of unconscious influences of memory. In the absence of any demonstration of unconscious influences of memory in this study, our results are consistent with the more parsimonious notion that the information supporting performance on direct and indirect tests of memory is accessible to consciousness and derives from a unitary memory system (Kinder & Shanks, 2001, 2003; Perruchet & Vinter, 2002; Shanks & St. John, 1994).

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