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Recognition Without Awareness: Encoding and Retrieval Factors

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The article reports 4 experiments that explore the notion of recognition without awareness using words as the material. Previous work by Voss and associates has shown that complex visual patterns were correctly selected as targets in a 2-alternative forced-choice (2-AFC) recognition test although participants reported that they were guessing. The present experiments sought to extend this earlier work by having participants study words in different ways and then attempt to recognize the words later in a series of 4-alternative forced-choice (4-AFC) tests, some of which contained *no* target word. The data of interest are cases in which a target was present and participants stated that they were guessing, yet chose the correct item. This value was greater than $p = .25$ in all conditions of the 4 experiments, demonstrating the phenomenon of recognition without awareness. Whereas Voss and colleagues attributed their findings with kaleidoscope patterns to enhanced processing fluency of perceptual attributes, the main factor associated with different levels of recognition without awareness in the present studies was a variable criterion for the subjective state accompanying selection of the "guess" option, depending on the overall difficulty of the recognition test. We conclude by discussing some implications of the results for the distinction between implicit and explicit memory.

Keywords: recognition, awareness, criterion shifts, implicit memory, explicit memory

In real-life decision situations we are often faced with alternatives that seem so equivalent that choice is extremely difficult. Under such circumstances our final selection may feel like an arbitrary choice, although in fact there may be implicit influences acting outside conscious control that bias us toward selecting one alternative over another. The observation that people can make correct choices while believing that they are selecting randomly has a long history in experimental psychology. Studies dating from the 19th century have consistently found that participants can make subtle perceptual discrimination judgments with above-chance accuracy despite claims that they are simply guessing (Adams, 1957; Voss & Paller, 2010). Voss and colleagues have recently provided evidence for a similar effect in recognition memory (Voss, Baym & Paller, 2008). Participants studied a series of kaleidoscope images and then attempted to recognize the studied items among a set of perceptually similar pairs. The study phase was performed under either full attention (FA) or divided attention (DA) conditions, and the recognition test was either a yes-no test (10 studied targets mixed with 10 similar foils) or a 2-AFC test (10 simultaneously presented target-foil pairs). In the yes-no test, recognition accuracy was good following encoding under FA conditions but very poor following DA at encoding, as one might expect in an explicit memory situation. Surprisingly, however, participants' performance on the forced-choice test was better following DA than FA at encoding. Further experiments revealed that when participants were asked to rate their forced-choice responses as being on the basis of some memory for the studied item or as random guesses, recognition accuracy was higher for responses judged to be guesses than for those thought to be based on memory.

These experiments thus provide evidence for substantial levels of recognition memory when participants believe they are simply guessing—that is, for recognition without awareness. This result was obtained only under very specific conditions, however—when encoding was performed under DA conditions, when the test was 2-AFC, when responding was under a tight time deadline (c. 2 sec from stimulus onset), and when the choice was between two perceptually similar visual patterns. There was essentially no evidence for the effect with a yes-no testing procedure or even with a forced-choice procedure when participants were given unlimited time to respond or when target stimuli were paired with a perceptually dissimilar foil (Voss et al., 2008, Experiments 3 & 4, respectively). A subsequent study revealed a further limitation; the effect was not obtained in the forced-choice procedure when participants were encouraged to respond accurately and guess only when absolutely necessary, although the original result reappeared when participants were encouraged to guess (Voss & Paller, 2010).

Voss and colleagues refer to their finding as "implicit recognition" and suggest that the underlying processes are different both

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from those mediating explicit recollection *and* from those mediating feelings of familiarity. They comment that "Familiarity-based recognition is taken as an instance of explicit memory because familiarity responses entail the awareness of memory retrieval" (Voss et al., 2008, p. 458). In support of the claim that implicit recognition has a different mechanism they cite a further study (Voss & Paller, 2009) in which participants performed the forced-choice test for kaleidoscope patterns, encoded under either FA or DA conditions. Participants in this study assessed each recognition choice as being associated with some explicit recollection of the encoding phase ("remember" = R), with a more general feeling of familiarity (they simply "knew" it had been studied = K), or as a pure guess. Event-related potential (ERP) recordings were also made during the recognition test. The results confirmed earlier findings of higher levels of accuracy following DA at encoding, and also of greater than chance accuracy levels with "guess" responses, especially in the DA condition. Additionally, the pattern of behavioral results in guess decisions was distinct from the pattern observed with both R and K decisions, suggesting that the mechanism associated with implicit recognition is different from that associated with recognition with awareness. The ERP results supported this claim. Recognition responses accompanied by feelings of recollection or familiarity were associated with positive shifts in the late positive complex (600–900 ms) and in the P200 potential. In contrast, correct guess responses were associated with frontal-occipital negative potentials occurring 200–400 ms after stimulus onset. The authors speculate that the distinct mechanism underlying the phenomenon of recognition without awareness may reflect a stimulus-specific enhancement of perceptual fluency (e.g., Jacoby & Whitehouse, 1989), with this subtle change in processing yielding enough information to support a correct recognition choice, although not enough to give rise to any conscious feeling of remembering.

A major question arising from this work is whether the phenomenon of recognition without awareness can be demonstrated with material other than complex perceptual patterns and, if so, whether it is associated with similar neural mechanisms. Is implicit recognition found with verbal materials, for example? In one early experiment, Peynircioğlu (1990) had participants study a list of words, and then gave them a word-fragment completion test in which some fragments were from the list and others were new. Participants attempted to complete the fragments and also rated each fragment with regard to whether it was based on a list member or based on a new word. Considering only fragments that were *not* completed, a higher mean rating was given to list than lure words. Thus, apparently participants had some sense of familiarity for the fragments even in the absence of identification. Subsequent work by Cleary and Greene (2004, 2005) showed that when studied and unstudied words were presented too quickly to identify in a perceptual identification test, participants could still discriminate studied from unstudied items. The authors attributed the effect to a greater sense of familiarity associated with the briefly flashed studied words. The finding that recognition without identification is associated with a specific ERP signal (Voss & Paller, 2009) was confirmed and extended to verbal material in a study using the method of Peynircioğlu (1990) and reported by Ryals, Yadon, Nomi, and Cleary (2011). The two major findings were, first, that for unidentified word fragments the proportion attributed to the original list was greater for studied than unstudied unidentified items; that is, recognition without identification (RWI) was again obtained. Second, the ERP correlate of the RWI effect was an N300 component of the evoked response, in agreement with Voss and Paller (2009) but using verbal materials and a yes-no recognition procedure. Ryals and colleagues concluded that their results confirmed the existence of unconscious recognition memory and that the RWI effect is indexed by the N300 ERP signature.

A study by Starns, Hicks, Brown, and Martin (2008) also found evidence for recognition without identification using verbal material. Their basic paradigm was to have participants study a list of words in which half of the words were printed in large font and half in small font (Experiment 1), or were rated for either pleasantness or imageability (Experiments 2 & 3). Participants were then given a recognition list composed of 50% studied words and 50% lures; additionally, half of the participants were informed that only 25% were targets and the other half informed that 75% were targets. Following this test, participants were re-presented with the original list and asked to decide the "source"—that is, whether each word had been in small or large font (or rated for pleasantness or imageability). The major finding was that participants' source judgments were above chance for words they had failed to recognize in the first test. Importantly, however, this effect was found only in the condition in which participants were informed that only 25% of the test words were targets. The authors concluded that the phenomenon of accurate source memory for unrecognized items is a reality, but that it occurs only under conditions in which a conservative response bias has been induced.

In summary, there is good evidence for the phenomenon of recognition without awareness, although the evidence associated with verbal materials is somewhat indirect in the sense that correct decisions about list membership were made on the basis of word fragments or the words themselves presented very briefly (Cleary and colleagues). Similarly, in the experiments by Starns et al. (2008) the evidence for recognition without identification comes from above-chance attribution of source rather than of the words themselves. One interesting question then is whether the phenomenon would extend to conditions in which participants correctly select words presented in full view despite claiming that they are simply guessing. This is the question addressed in the present experiments.

We became interested in these findings when considering the results of an earlier set of experiments reported by Gopie, Craik and Hasher (2011). In that study, younger and older adult participants first named the print color (red, green, blue, yellow) of a series of words as rapidly as possible; they were informed that the words themselves were irrelevant. This encoding phase was followed by a word fragment completion test, containing fragments of words from the "encoded" list as well as new word fragments. The higher completion rate for repeated words than for new words (priming effect) was greater for older adults (0.25) than for younger adults (0.10), in line with the notion that older adults fail to inhibit "irrelevant" information, which they can subsequently use if that information becomes useful (Hasher, Zacks & May, 1999). Surprisingly, however, this pattern reversed in a second experiment using the same color-naming initial phase, but with explicit instructions to "use words from the initial list where possible" in the fragment-completion test. Now younger adults had a priming score of 0.24 and older adults' score dropped to 0.08.

The same Age × Implicit/Explicit interaction was replicated in a further experiment.

What is the nature of the encoded verbal information in the incidental color-naming situation? It is well established that implicit verbal tests such as fragment completion are particularly sensitive to perceptual information (e.g., Craik, Moscovitch & McDowd, 1994; Schacter, Dobbins, & Schnyer, 2004), and the successful priming shown by older adults suggests that they may have encoded words in the color-naming phase in a perceptual manner. When younger adults performed the color-naming task under DA conditions, their subsequent fragment-completion performance resembled that of older adults (implicit completion = 0.22, explicit completion = −.03; Gopie et al., 2011, Experiment 3), again suggesting that the DA condition induced a somewhat superficial encoding of the words. This DA condition obviously resembles the DA conditions used by Voss and colleagues, and the finding of successful fragment completion subsequent to this type of encoding fits well with Voss and colleagues' characterization of their recognition without awareness as reflecting enhanced perceptual fluency. These initial findings prompted the question of whether recognition without awareness would be observed if the color-naming initial phase was followed by an *explicit* recognition test. Would participants select a previously viewed word at greater than chance levels while claiming that they were simply guessing? The following experiments investigated this possibility.

A further purpose of the present series of studies was to obtain more information about the types of representation associated with implicit recognition, and the factors that affect the size of the effect. The similarities and differences between effects obtained with words and with kaleidoscope patterns should suggest commonalities and limitations among the various representations underlying implicit recognition effects. The results may also point to differences in the representations associated with implicit and explicit memory for the studied items. Do such differences reflect the involvement of different memory systems, for example (e.g., Tulving & Schacter, 1990), or simply differences in the types or amounts of information the representations contain about the original episode (e.g., Chechile, Sloboda & Chamberland, 2012)?

With regard to factors that might influence the size of the effect, we were influenced by two findings from previous studies and one conjecture of our own. First, we presented words in an initial encoding phase under either full or divided attention conditions (FA or DA). The reasons for this followed the stronger effects observed by Voss and colleagues under DA conditions, also the possibility from the studies by Gopie et al. (2011) that DA induces a more superficial perceptual encoding. We speculated that recognition without awareness for words might also be stronger following such conditions. Second, the results of Starns et al. (2008) provided strong evidence that the effect would be greater under conditions of conservative responding in the test phase, so our results were examined with this point in mind. Finally, in line with the notions of encoding specificity (Tulving & Thomson, 1973) we hypothesized that the effect would be stronger to the extent that the encoding and test conditions were different, so this factor was also incorporated in our design. The rationale for this last point is described in the next paragraph.

To illustrate the phenomenon of recognition failure of recallable words, Tulving and Thomson (1973) first presented target words as response items in a paired-associate list. Next, in an apparently unrelated phase of the experiment, participants were given cue words and asked to generate four free associations to each cue word. The cues were chosen so that the generated associations often matched response words in the previous paired-associate list. In the third phase, participants were asked to read through the words they had generated and circle any they recognized as the previously learned words. Finally, they were given the original paired-associate stimulus words as cues to recall the appropriate responses. The main result was that participants often failed to recognize generated target words in Phase 3, although the same words were recalled in response to the original paired-associate cues in the final phase. The authors' interpretation of this striking result was that target words encoded specifically as responses in a paired-associate list were not perceived subjectively as the same words when encountered again as their own generated associations. Essentially, the context change between encoding and test acted to reduce recognition. Applying this thinking to the phenomenon of recognition without awareness, our conjecture was that a similar change of context between initial encoding and the recognition test might result in a failure of explicit recognition, but allow the participant to still select the correct target word in a forced-choice test by virtue of implicit recognition. This notion predicts that greater amounts of context change between encoding and test would be associated with increased recognition failure but also an increased likelihood of 'recognition without awareness.'

In order to provide a sensitive test of recognition memory, and to allow for the possibility of recognition without awareness, we used the testing procedure devised by Tulving and Thomson. In the present studies, participants were shown a series of 4-word sets and instructed to choose the one word they may have encountered in the first (encoding) phase. They were also told (correctly) that some of the 4-word sets contained *no* target, but that they must still select one word as the most likely to have been in the first phase. To make sense of this procedure, participants were also instructed to give a confidence rating for each choice, in which 2 = "fairly certain it was on the list," 1 = "possibly on the list," and 0 = "pure guess—I was forced to choose one." In a 4-AFC situation, chance responding will yield $p = .25$, so the interest in the present experiments is in cases in which target items *are* present, participants give a rating of 0, yet choose correctly at a level higher than 0.25. In line with the previous literature, we will refer to such outcomes as 'recognition without awareness.' Experiments 1 and 2 utilized the color-naming procedure reported by Gopie et al. (2011) as the encoding phase, and in the final two experiments we used the paired-associate learning task reported by Tulving and Thomson (1973).

Experiment 1

Method

Participants. The participants were 48 undergraduates from the University of Toronto who participated in the experiment for course credit. Their mean age was 18.9 years, and mean score on the Shipley vocabulary scale (Zachary, 1986) was 29.1. Participants were randomly assigned to the FA or DA condition, $n = 24$ per condition.

Design and procedure. The experiment consisted of two phases; incidental encoding followed by a 4-AFC recognition test. These phases were separated by a 10-min retention interval in which participants played the Tetris computer game. The first phase was described as a color-judgment experiment, in which participants were presented with a series of 40 common nouns whose font color was red, blue, green or yellow. The task was to judge the color of each word as it appeared in the computer monitor and to respond as rapidly as possible by pressing one of four response buttons. Following each response there was a 1,000 ms intertrial interval before the next word appeared. The words themselves were described as being irrelevant to the task. Half of the participants performed the task under FA conditions, and half under DA conditions. The DA task was to listen to a string of auditory digits presented at a 1.5 s rate, and detect targets defined as three successive odd digits (e.g., 7–9–5, 1–3–1, etc.). DA participants signaled detection of an auditory target by pressing the space bar.

After completing the color-judgment task, all 48 participants played the computer game Tetris for 10 min. They then all performed an explicit recognition memory task under full attention conditions. The recognition test contained 50 4-AFC trials; participants were instructed to select one of the four words in *all* cases—a word that may have been an ignored color word in the first phase. Of the 50 trials, 40 did contain one target word from the study phase, and 10 contained no target words. Participants were informed that on certain trials no target word would be present, but that they should always choose the word they judged to be the most likely from Phase 1. Participants were also asked to rate their choice as a word they were "fairly certain" had been in Phase 1, as "possibly there" or as a "pure guess." These ratings were coded as 2, 1, and 0, respectively.

Results

When a target word was present among the four choices, participants rated their choice as a "pure guess" on an average of 19.1 trials out of 40 (48%) in the FA condition and 20.9 trials (52%) in the DA condition. In these cases the proportions of correct choices were 0.27 and 0.33 for FA and DA conditions, respectively; that is, the proportions of correct selections were 0.27 and 0.33, given that a target word was present and that the selection was made with zero confidence. The proportions of "pure guess" judgments in this and the following experiments are given in Table 1 under the heading "Prop. 0." The values of correct selections given a confidence rating of zero are referred to as $p(c)|0$, and these values are also given in Table 1. The chance value is 0.25, and *t* tests showed that the 0.27 value was not significantly different from 0.25, $t(23) = 0.80$, $p > .05$, whereas the value of 0.33 was reliably different from chance, $t(23) = 4.82$, $p < .001$. Additionally, the DA value of 0.33 was significantly higher than the FA value of 0.27, $t(46) = 2.11$, $p < .05$. When a target was present in the set, the conditional probabilities of choosing it correctly given a confidence rating of 1 ("possibly there") or 2 ("fairly certain") were 0.35 and 0.49, respectively, for FA participants, and 0.32 and 0.43, respectively, for DA participants. Thus performance was above chance but far from perfect when participants claimed some memory awareness of their choices.

Table 1
Performance Measures in Experiments 1--4

Experiment	Hit rate	Prop."0"	$p(c)|0$	Prop. "1 + 2"	$p(c)|1 + 2$
Experiment 1					
FA	0.34	0.48	0.27	0.52	0.20
DA	0.34	0.52	0.33	0.48	0.13
Experiment 2					
FA	0.58	0.26	0.39	0.74	0.56
DA	0.35	0.39	0.30	0.62	0.19
Experiment 3					
FA	0.69	0.26	0.40	0.74	0.75
DA	0.57	0.31	0.34	0.69	0.59
Experiment 4					
FA	0.85	0.17	0.41	0.83	0.91
DA	0.84	0.15	0.43	0.85	0.88

Note. Overall hit rate is defined as correct selection of a target item regardless of confidence rating (0 + 1 + 2). Prop. "0" = proportion of choices rated zero; p(c)|0 = probability of choosing correctly, given a '0' confidence rating; Prop. "1 + 2" = proportion of choices rated 1 or 2; $p(c)|1 + 2$ = probability of choosing correctly, given a confidence rating of 1 or 2. These last values are corrected for chance responding (see text).

Discussion

The major finding of interest was that participants in the DA condition did exhibit some degree of recognition without awareness. In that condition, 18 participants had values of correct choices rated as a "guess" that exceeded the chance level of 0.25 whereas only four participants had values less than 0.25. The finding of more recognition without awareness following DA conditions at encoding echoes the findings of Voss and colleagues, and is in line with the idea that this encoding condition may have yielded superficial perceptual encodings of words. Arguably, this type of encoding may be sufficient to choose target words correctly in a later forced-choice recognition test, but insufficient to yield the subjective experience of remembering. In order to obtain further evidence on this phenomenon we replicated the study in a second experiment, but with the one difference that participants were informed in the first color-judging phase that memory for the words would be tested later. Our assumption was that this change would result in more deliberate encoding of the words, and therefore an increase in hit rate in the recognition test. We also predicted that this stronger encoding would be associated with a decline in the proportion of "0" responses (because of the increased hit rate) and a reduction in the propensity to select target words while apparently guessing (following our assumption that intentional encoding in the first phase would result in a greater match between encoding and retrieval).

Experiment 2

Method

The design and procedure were exactly as in Experiment 1, including the FA and DA conditions, but with the one alteration that participants were informed before performing the color-judgment task that there would be a memory test for the colored words. The participants were again undergraduates who participated for course credit; 24 were tested in the FA condition (mean age = 19.0 years; Shipley vocabulary = 29.5) and 21 were tested in the DA condition (mean age = 19.3 years; Shipley vocabulary = 30.1).

Results

When a target word was present, participants rated their choice as a "pure guess" 10.5 times, on average, out of a possible 40 trials in the FA conditions and 15.2 times, on average, in the DA condition. Thus the measures of proportion "0" were 0.26 and 0.39, respectively (see Table 1). In these "pure guess" cases, the mean proportions of correct choices were 0.39 in the FA condition and 0.30 in the DA condition (see Table 1). Although both of these $p(c)|0$ values exceed the chance value of 0.25, only the FA value was significantly higher than 0.25, $t(23) = 2.85$, $p < .01$; the DA value was not significantly greater than chance, $t(20) = 1.56$, $p > .05$. In addition, the FA value of 0.39 was not significantly higher than the DA value of 0.30, $t(43) = 1.54$, $p > .05$. The proportions of correct selections made with confidence ratings 1 and 2 when targets were present were 0.44 and 0.84, respectively for the FA condition, and 0.31 and 0.57, respectively for the DA condition. These "aware" values are understandably higher than the corresponding values in Experiment 1.

Three 2 (FA/DA) × 2 (Experiments 1 & 2) analyses of variance (ANOVAs) were also carried out to compare the values of hit rate, proportion "0" and $p(c)|0$ between the experiments. Hit rate was defined as the probability of selecting the correct target when one was present, regardless of confidence rating. The ANOVA on hit rates showed a significant effect of experiment, $F(1, 90) = 42.12$, $p < .001$, $\eta_p^2 = .32$, of FA/DA, $F(1, 90) = 33.47$, $p < .001$, $\eta_p^2 = 0.27$, and the interaction between the two factors, $F(1, 90) = 32.02$, $p < .001$, $\eta_p^2 = .26$. Table 1 indicates that these effects show that hit rates in Experiment 2 were generally higher than those in Experiment 1, and also that hit rates were higher for FA than DA conditions. However, these effects were modulated by a significant interaction between the factors; only the FA condition in Experiment 2 showed the benefit of intentional learning conditions. The ANOVA on proportion "0" scores revealed significant effects of experiment, $F(1, 90) = 21.06$, $p < .001$, $\eta_p^2 = .19$, and of FA/DA, $F(1, 90) = 4.78$, $p < .03$, $\eta_p^2 = .05$, but no interaction, $F(1, 90) = 1.11$, $p > .05$. That is, values of proportion "0" were higher for Experiment 1 than for Experiment 2, and somewhat higher for DA conditions than for FA conditions (see Table 1). The ANOVA on $p(c)|0$ values showed that neither the effect of Experiment, $F(1, 90) = 1.68$, $p > .05$ nor FA/DA ($F < 1.0$) was significant, but the interaction was statistically reliable, $F(1, 89) = 5.58$, $p = .02$, $\eta_p^2 = .06$. Table 1 shows that this last effect is attributable to the value for DA being higher than that for FA in Experiment 1, but that FA is greater than DA in Experiment 2.

Discussion

Our predictions for Experiment 2 relative to the first experiment were that the intentional learning instructions in the color-judgment phase would increase the hit rate, reduce the proportion of "0" confidence ratings, and also reduce the value of proportion correct, given a "0" rating [$p(c)|0$]. The first two predictions were borne out by the results, although the hit rate increase was found only for FA conditions. The prediction that $p(c)|0$ would decrease was *not* upheld, however. There was no main effect for experiment, but the significant interaction between Experiment and FA/DA showed that $p(c)|0$ increased from 0.27 to 0.39 in the FA condition but declined slightly (from 0.33 to 0.30) in the DA condition. The speculation that recognition without awareness might decrease as a function of a better match between encoding and test conditions was, therefore, not supported by these results. Our assumption was that the intentional encoding instructions in Experiment 2 would be more similar than the incidental conditions in Experiment 1 to the intentional recognition conditions at test, and so $p(c)|0$ should decline from Experiment 1 to Experiment 2, which generally did not happen.

Another initial prediction was that the probability of recognition without awareness would be greater in DA than in FA conditions. This prediction was supported marginally in Experiment 1, but the probabilities of $p(c)|0$ reversed in Experiment 2 where the values were 0.39 for FA and 0.30 for DA. The difference was not significant, but was nevertheless in the wrong direction. The proportion of guess responses did drop substantially as the potential to learn the words in Phase 1 increased. In turn, this result raises the possibility that the subjective meaning of a guess response might change as a function of how well words were learned. The possibility that such a change in criterion might signal a shift to more conservative responding in line with the conclusions of Starns et al. (2008) is considered again after describing two further experiments.

Despite obtaining results from the two color-word experiments that gave little support to the notions of either context change or encoding under DA conditions as a basis for recognition without awareness, we decided to change the encoding paradigm before abandoning the ideas. Accordingly, we ran two experiments using a paradigm that was closer to the paradigm used by Tulving and Thomson (1973). One difference was that in our version the test words were provided rather than generated by the participants. The paradigm thus consisted of several paired associate lists in the encoding phase followed by a test phase consisting of a series of 4-AFC recognition tests. To encourage the use of the "pure guess" ("0") response, only half of the test trials contained a target, and participants were informed of this fact. Experiment 3 was the first study using this paradigm, and so was basically exploratory in nature.

Experiment 3

Method

Experiment 3 again contained an encoding phase followed by a test phase. In this case the first phase consisted of a series of paired-associate lists, and this phase was followed by a 4-AFC recognition test for words on the final list. The participants were 48 young adults (undergraduate students) who were allocated randomly to one of two conditions, FA and DA, during the learning phase. The FA condition had 24 participants (mean age = 18.8 years; years of education = 12.3) and the DA condition also had 24 participants (mean age = 18.6 years; years of education = 12.5). The materials used for the paired-associate lists were common words (mostly nouns) of 1–3 syllables and ranging in frequency from 10 (coin) to 1,207 (man) according to the Kučera and Francis (1967) norms. During the encoding phase, participants studied two lists of 24 paired associates (Lists 1 & 2) presented visually at a 5 s rate with a 1 s interstimulus interval. Participants in the DA condition also performed the "successive-odd-digits" task presented auditorily while learning the lists. In this case the DA task was made slightly easier by asking participants to detect the presence of two successive odd digits. At the end of each list all participants completed a self-paced cued-recall test. List 3 had 48 paired associates presented in the same way, but at the end of presentation participants were informed that we were interested in the effects of time delay on memory, and that the recall test would come later. In the meantime, they played the computer game Tetris for 5 min.

Participants were then given 48 sets of four words on two sheets of paper. Half of the sets contained a response word from List 3; the other half contained no target words. There were two versions of the 4-AFC recognition test (A & B); 24 participants (12 FA and 12 DA) received Version A, which contained 24 List 3 response words, and the remaining 24 participants received Version B, which contained the target words not on A. Participants were asked to circle one word in each set of four, the word most likely to come from List 3. They were informed that only half of the 4-word sets contained a target, but they should always select one, guessing when necessary. They were also instructed to provide a confidence rating with each word, with 0, 1, 2 having the same meaning as in Experiments 1 and 2. Finally, they were given the cued-recall test for the original List 3.

Results and Discussion

Paired associate recall probabilities were 0.36, 0.61 and 0.43 for Lists 1, 2, 3, respectively, for the FA group, and 0.12, 0.36, and 0.26, respectively, for the DA group. Thus, as expected, the recall values for DA participants were consistently lower than the corresponding values for FA participants.

As shown in Table 1, hit rates were 0.69 and 0.57 for the FA and DA groups, respectively. Thus intentional learning of paired-associate responses presented at a relatively slow rate (6 s per pair) was associated with higher hit rates than those obtained from the first two experiments. Proportions of target words recognized correctly with confidence ratings 1 and 2 were 0.58 and 0.94, respectively, for the FA group, and 0.55 and 0.79, respectively, for the DA group. All of these values were reliably higher than 0.25, all values of $t > 6.50$. Table 1 also shows that the proportion of words selected with zero confidence on the 24 trials when a target word was present was 0.26 for FA participants and 0.31 for DA participants. When a target word was present and the selection was made with zero confidence, participants were correct with proportions 0.40 for the FA group and 0.34 for the DA group. These values are shown in Table 1 under the heading $p(c)|0$. The 0.40 value for FA was greater than the chance value of 0.25, $t(22) = 2.73$, $p < .01$; but the 0.34 value for DA was not reliably greater than chance, $t(23) = 1.60$, $p = .12$. From the point of view of the context change hypothesis, it is unclear whether the shift between paired-associate learning and the 4-AFC test is more or less than the shift between color-word naming and the test, so the final experiment was designed to provide a clearer test of this hypothesis. For now it may be noted that the value of $p(c)|0$ was again higher for the FA group than for the DA group, again providing no evidence for the notion that recognition without awareness is associated with DA at encoding. The third hypothesis, that the incidence of recognition without awareness is restricted to conditions of conservative responding (Starns et al., 2008), is difficult to assess from these data; consideration of this possibility is deferred until the final experiment is described.

The major purpose of Experiment 4 was to provide a strong test of the context shift account by making conditions for the 4-AFC test as compatible as possible with the encoding conditions. This was accomplished by reminding participants of the original paired-associate pairs at the time of the recognition test. We did this by preceding each set of four words in the 4-AFC test with a stimulus word from the original learned list. When a target word was present in the set it was always preceded by its correct stimulus word from the original List 3 learning trial. Thus, if the original pair to be learned was moth-FOOD, the four words provided for the recognition test (BASE, FOOD, BOOK, FARM) would be preceded by "moth." When a target word was not present, the recognition set was composed of four new words preceded by a randomly chosen stimulus word from the original paired-associate list. By reinstating the learning context in this way we expected to increase the hit rate but greatly reduce the phenomenon of recognition without awareness.

Experiment 4

Method

Experiment 4 was a replication of Experiment 3, with the one change that each set of four words in the 4-AFC recognition test was preceded by a stimulus word from the 48 pairs to be learned in List 3. In the 24 cases that a target word was present, the stimulus word was its correct pair mate; the remaining 24 4-AFC cases (which contained no target words) were paired randomly with the remaining 24 stimulus words. As in Experiment 3, half of the participants were given the A set of 4-AFC choices and half were given Set B. Forty-eight participants age 18–28 years participated in the study. Half of them were assigned to the FA condition (mean age = 21.8 years, mean years of education = 14.8) and half to the DA condition (mean age = 21.3 years, mean years of education = 14.8). The DA group again performed the auditory monitoring task ("tap the table every time you hear 2 successive odd digits") while learning the initial three paired-associate lists.

Results and Discussion

The overall recognition performance in this cued 4-AFC situation was predictably high—85% correct for FA and 84% correct for DA participants (hit rates in Table 1). Nevertheless, participants did rate their confidence level as zero in a number of instances when a target was present; the proportions were 0.17 for the FA group and 0.15 for the DA group (proportion "0" in Table 1). For the 21 participants in the FA group who selected items with zero confidence, the proportion of correct choices was 0.41; this value was significantly greater than the chance value of 0.25, $t(20) = 3.31$, $p < .01$. For the 18 DA participants who selected items with zero confidence, the proportion was 0.43, and the associated significance value was $t(17) = 3.38$, $p < .01$. Clearly these values of $p(c)|0$ did not fall close to 0.25 as predicted, and are broadly comparable to the results of Experiment 3, despite the apparent success of the contextual reinstatement manipulation—overall recognition rates rose from 69% to 85% for FA participants in Experiments 3 and 4, respectively, and from 57% to 84%, respectively, for DA participants.

Other results made sense in light of the easier conditions associated with the cued 4-AFC procedure. Probabilities of correct recognition given confidence ratings 1 and 2 were 0.60 and 0.99, respectively, for FA participants, and 0.61 and 0.99, respectively, for DA participants. Cued recall probabilities for Lists 1, 2, and 3 were 0.43, 0.62, and 0.54, respectively, for FA participants, and 0.20, 0.44, and 0.44, respectively, for DA participants. Thus the DA manipulation reduced recall values, as in the previous experiments, but it is interesting to note that the manipulation did not reduce recognition scores in this instance. Apparently, the combination of context reinstatement with the forced-choice procedure was sufficient to compensate for the poorer initial encoding revealed in the cued recall cases.

Three ANOVAs were conducted to compare the results of Experiments 3 and 4. Each was a 2 (Experiments 3 & 4) × 2 (FA vs. DA) between subjects analysis. For overall hit rates, there was a significant effect of Experiment, $F(1, 92) = 44.70$, $p < .001$, $\eta_p^2 = .33$, and marginally reliable effects of FA/DA, $F(1, 92) = 3.23$, $p < .08$, $\eta_p^2 = .03$, and the interaction between the factors, $F(1, 92) = 2.90$, $p < .10$, $\eta_p^2 = .03$. Table 1 shows that these effects signify that hit rates were higher in Experiment 4 than in Experiment 3, and that there was a trend for these values to be higher for FA than for DA, especially in Experiment 3. For the measure proportion "0," the ANOVA yielded a significant effect of Experiment, $F(1, 92) = 14.91$, $p < .001$, $\eta_p^2 = .14$, but no effects of either FA/DA ($F < 1.0$) or of the interaction, $F(1, 92) = 1.79$, *ns*. Table 1 shows that the proportion of zero responses was greater in Experiment 3 than in Experiment 4. For the measure $p(\text{c})|0$, the effect of Experiment was not significant, $F(1, 82) = 2.63$, $p > .05$, and neither the effect of FA/DA ($F = 1.08$) nor the interaction ($F < 1.0$) approached significance.

But the major result of interest is that the greater amount of contextual reinstatement from Experiment 3 to Experiment 4 had no effect on the values of $p(\text{c})|0$. The contextual reinstatement manipulation clearly worked, given the substantially higher levels of overall recognition in the present experiment, but there was no evidence for a reduction in 'recognition without awareness.' The hypothesis that recognition without awareness in these paradigms might be akin to the phenomenon of recognition failure in the Tulving and Thomson (1973) experiments was therefore not supported by the present results, or at least not in the version that proposes that the size of the effect should be reduced as the encoding and retrieval contexts are made more similar. Over the four experiments, there is thus little or no support for either the context change hypothesis or the notion that recognition without awareness is more likely to occur under conditions of DA at encoding. The remaining hypothesis, that the value of $p(\text{c})|0$ rises as recognition decisions are made under more conservative criteria, is considered in the General Discussion that follows.

General Discussion

A consideration of the data from all four experiments (see Table 1) shows clearly that our measure of recognition without awareness [$p(\text{c})|0$] does not vary systematically with FA/DA at encoding, and there is also little evidence for the notion that $p(\text{c})|0$ varies as a function of context shift between encoding and retrieval. However, another possibility stems from the idea that there may be criterion shifts in the likelihood of giving a zero confidence response. In particular, it seemed possible that the criterion may depend on the overall ease or difficulty of the final 4-AFC recognition test. Presumably easy tasks will yield many 1 and 2 judgments when targets are present, and relatively few 0 judgments. But for easy tasks, targets are typically rather obvious and will be rated 1 or 2. If an item is less obvious, it may be chosen but given a zero confidence rating when contrasted with easier items. This thinking predicts a relationship between overall difficulty of the recognition test and values of $p(\text{c})|0$—easy tasks should give relatively few "0" judgments, but a high value of $p(\text{c})|0$.

Table 1 shows that the overall hit rates rise generally from Experiment 1 to Experiment 4, indicating that there was a tendency for the tasks to become easier. The Table also shows a tendency for the proportion of "0" responses when a target was present to decline from the first to the last experiment (understandably, as participants made more confident 1 or 2 responses as task difficulty decreased) and also for the measure $p(\text{c})|0$ to increase from Experiments 1 to 4. These trends were assessed by carrying out a series of Spearman's rho correlation coefficients among the variables, using the means of the eight conditions (4 Experiments × FA/DA). The correlation between hit rate and proportion "0" was rho (6) $= -0.94$, $p < .01$ and the correlation between hit rate and $p(\text{c})|0$ was rho (6) $= +0.93$, $p < .01$ (Figure 1a and 1b, respectively). Additionally, the correlation between proportion "0" and $p(\text{c})|0$ was rho (6) $= -0.91$, $p < .01$. There is thus good evidence across the eight conditions that as the task became easier (measured by increasing hit rate), the proportion of "0" confidence responses declined and the values of $p(\text{c})|0$ correspondingly increased. Also, it is the case that values of p(c)|0 increased systematically as the proportion of "0" responses declined.

Further insight into the processes operating in the experiments may be gained by considering the relations between hit rates and the proportions of responses given 1 or 2 ratings when a target was present, and also between hit rates and the proportions of these 1 or 2 responses that were actually correct [$p(\text{c})|1 + 2$]. The proportions given either 1 or 2 confidence responses are simply the complements of the proportions given zero responses, and are shown in column 4 of Table 1. These values signal the occasions that participants thought they had chosen the correct item. In order to compare the values of proportion correct given 1 or 2 [$p(\text{c})|1 + 2$] with the proportions chosen with 1 or 2 confidence ratings, we corrected values of $p(\text{c})|1 + 2$ for chance. Specifically, for each condition we first calculated the proportion correct given a rating of 1 or 2; we then subtracted the chance value of 0.25 from that proportion, and divided the result by 1.0 minus chance (0.75). The resulting scale of proportions correct given a 1 or 2 rating thus runs from 0 to 1.0, as does the scale of proportions of 1 or 2 chosen. The corrected values of $p(\text{c})|1 + 2$ are shown in column 5 of Table 1. These values, and also the proportions of 1 or 2 chosen, are plotted against overall hit rate in Figure 2.

The figure shows that both functions are well fit by linear functions, but with different slopes. At lower values of hit rate (difficult tasks) the proportions correct are around 0.15–0.20, whereas the proportions of selections made with1 or 2 confidence ratings are between 0.45 and 0.55. That is, the relatively high

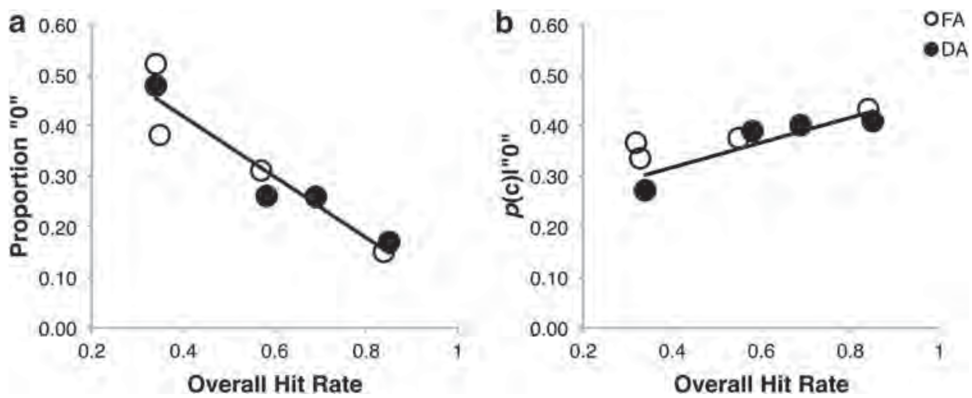

Figure 1. (a) Proportions given "0" ratings, and (b) p(c)|"0" (proportions correct given ratings of "0"), as a function of overall hit rate for the FA and DA conditions.

confidence levels are unwarranted by the proportions actually correct. This discrepancy reduces, however, as the tasks get easier, until at higher levels of hit rate (relatively easy tasks) the proportions of choices made with 1 or 2 ratings are slightly lower than the corresponding proportions correct. That is, participants are somewhat conservative in their allocation of confidence ratings at the easy end of task difficulty. This observation is in line with previous reports that stricter criteria are typically applied to strongly encoded stimuli and thus easier detection and recognition performance (Singer, 2009). On the assumption that trials themselves vary on a continuum of difficulty for each person in a given experiment, this pattern implies that for low values of hit rate participants allocate more ratings of 1 and 2 than they "ought to" given the difficulty level, so the remaining "0" allocations are given to the most difficult trials, and correspondingly show a low probability of being correct. When hit rates are high, however, the pattern reverses. Now participants allocate fewer ratings of 1 and 2 to choices than they might do given the relatively easy tasks, and so the remaining "0" allocations are given to trials that are also

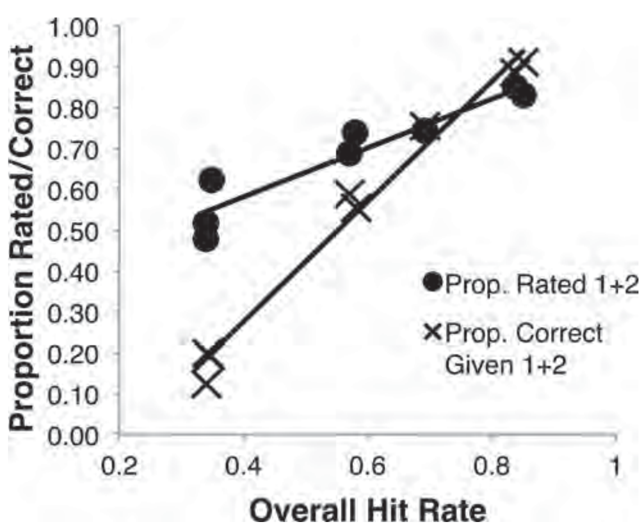

Figure 2. Proportions rated 1 or 2, and proportions correct given 1 or 2 ratings, as a function of overall hit rate.

relatively easy and so show a higher hit rate. In summary, we suggest that the strong correlation between overall hit rate and p(c)|0 is a function of a changing criterion for the allocation of "0" responses (Singer, 2009). The probability of 'recognition without awareness' increases as the tasks become easier, and participants adopt a more conservative criterion for claiming that they have chosen an item from the encoding list.

How general is this criterion account of recognition without awareness? It is clearly compatible with the results of Starns and colleagues (2008) who explicitly concluded that source memory for unrecognized items varied with the bias to respond "old" in recognition decisions. In their case the phenomenon appeared only under conditions that promoted conservative responding. The present account is probably less applicable to the studies by Cleary and Greene (2004, 2005) and by Ryals et al. (2011) who showed recognition of list membership in the absence of identification on the basis of processing word fragments or speeded processing of the words themselves. In these cases the recognition of list membership is probably due to an unconscious recognition memory process, possibly attributable to a minimal sense of familiarity as the authors suggest.

With regard to the studies of Voss and colleagues (Voss et al., 2008; Voss & Paller, 2009, 2010), we agree with those authors that the term "implicit memory" should be reserved for cases in which individuals' performance shows evidence of memory for previous events, yet they are unaware that their responses are based on memory. By this definition, choices accompanied by feelings of either recollection or familiarity (or given with either "remember" or "know" responses) are classified as cases of explicit memory. On the contrary, correct choices made but classified as 'guesses' are instances of implicit memory—recognition without awareness. Such instances were documented both by Voss and colleagues and in the present experiments.

Voss and Paller (2010) consider, but reject, the possibility that recognition without awareness is simply based on the processing of relatively weak representations that might otherwise evoke responses of familiarity or recollection (see also Voss, Lucas & Paller, 2012). Their arguments are based partly on different ERP signatures related to implicit memory compared to those associated with familiarity and recollection (Voss et al., 2012), but also to the changes in R, K, and guess responses between conditions in which guessing was either encouraged or discouraged. In the latter case, the probability of a guess response being accurate was $p = .43$ (less than chance in a 2-AFC paradigm), whereas when guessing was encouraged the accuracy of responses classified as guesses rose to $p = .78$ (Voss & Paller, 2010). Interestingly, the proportions correct for R and K responses did not change systematically between the two encouragement conditions: for R responses the proportions correct were 0.80 under "confidence encouraged" instructions and 0.76 under "guessing encouraged " instructions; the corresponding proportions for K responses were 0.60 and 0.62, respectively. The authors argue that this result is not consistent with a simple shift in criterion. However, an alternative reading of the result is that whereas the encouragement to guess led to an increase in the rate of guessing (from 12% to 26%) and a concomitant decrease in the rates for R and K responses, the subjective criteria for K and R responses (based on proportions correct) remained relatively unchanged, whereas the encouragement to use the "guess" response allowed participants to select that response more often. It is also necessary to add that the subjective criterion for "guess" must have changed, such that under encouraging conditions items that might otherwise be classified as K or R are now classified more cautiously as guesses, with a consequent rise in the probability that such responses are correct. Our suggestion is therefore that encouragement to guess differentially changes the criterion for what constitutes a 'guess' response but leaves the subjective labels unchanged for K and R responses.

Conditions under which recognition without awareness was *not* observed in the studies reported by Voss and colleagues include recognition of kaleidoscope patterns using a yes-no procedure, using a 2-AFC procedure when the two choices were perceptually very different, and when participants were given an extended time to decide. All of these cases likely engender a deliberate conscious retrieval strategy rather than a reliance on perceptually based implicit recognition. Voss and Paller (2009) boost their case for a perceptual basis of their implicit memory demonstrations by showing that the neural correlates of the effect included frontal-occipital brain potentials at 200–400 ms post-stimulus-onset, potentials that were distinct from the late positive responses associated with judgments of recollection or familiarity. Given that these researchers used complex and relatively meaningless kaleidoscope patterns as stimuli it makes sense that recognition choices were made on the basis of perceptual processing.

In our own case the stimuli were words, the four choices presented on each test trial were not perceptually similar, and participants performed the sequence of 4-AFC test trials at their own pace, rather than under time pressure. In addition, Table 1 makes it clear that there were no systematic changes associated with encoding under full versus divided attention in our experiments. It thus seems clear that implicit recognition can occur with a variety of materials and under a variety of experimental conditions. One way of reconciling the present results with those of Voss and Paller is to suggest that the selection of a correct item is based on processing the relevant neural representation in all cases, although of course the nature of that representation will vary widely. We also suggest that such representations are the basis for correct selection for *both* implicit and explicit recognition memory; the difference between the two types is that explicit memory is accompanied additionally by some representation of the context of initial occurrence—either a nonspecific feeling of past occurrence in the case of K responses or specific recollection of context for R responses. Speculatively, this second type of representation may be associated with changes in the neural activations recorded as the late positive complex in the ERP signals reported by Voss and Paller (2009). In turn, various factors will contribute to the encoding and retrieval of such contextual representations; they may include such things as attention to contextual attributes during encoding, the associative relationship of the target item to its initial context, the degree to which the retrieval context matches the encoding context, and the extent to which the participant engages deliberate attempts to recollect the initial situation. These, of course, are among the factors studied by many researchers investigating the characteristics of explicit recollection.

The point we wish to stress here is that two distinct sets of factors may be operating to give rise to the phenomenon of recognition without awareness; one set contributes to the relative strengths (or degrees of fluent processing) of representations of target items and their lures, the second set contributes to the occurrence and adequacy of representations of the initial encoding contexts of these target items. According to this view, recognition without awareness will occur when item representations are strongly present (or are processed fluently), but contextual representations are weak or absent. In the Voss and Paller experiments, participants deliberately attempted to learn the kaleidoscope patterns so good item representations were established. It seems likely, however, that the corresponding contextual representations were poorly differentiated among the various very similar items, enabling participants to select a target item correctly but in the absence of any feeling of recollection that it was one they had studied. The encoding of well-differentiated contextual representations would be even less likely under divided attention conditions, and the retrieval of such representations would be poor under conditions that discouraged a deliberate analytic retrieval strategy—for example, the speeded 2-AFC conditions used in the Voss and Paller studies.

In the case of the current experiments, participants were presumably able to form good item representations under the intentional learning conditions of Experiment 2, 3, and 4. Context information was also available at encoding but this information may have been difficult to access at retrieval given that the items were now presented in a very different 4-AFC context. Additionally, we suggest that the probability of correctly selecting a target item with zero confidence varied with the overall difficulty of the particular recognition test, and a concurrent shift in the criterion associated with the subjective feeling of what constitutes a "guess" response. Voss and Paller (2012) suggest that their effects are based on fluency of perceptual processing of the encoded representations, and this seems very reasonable given that the items were complex and relatively meaningless visual patterns. In the present case, the correct selection of the target word when confidence was zero may also be attributable to the greater perceptual fluency of processing targets relative to lures (Jacoby and Whitehouse (1989). Alternatively, Chechile, Sloboda, and Chamberland (2012) have suggested that implicit and explicit recognition differ simply in the adequacy (e.g., strength, vividness) of the encoded representation, with weakly represented items being insufficient to support explicit recognition, but still sufficient to select the correct item while claiming that the choice was simply a guess. We add to the Chechile et al. model by suggesting that the criterion for a "guess" response is variable as described earlier, but differ from them by suggesting that explicit recognition also involves the retrieval of a further representation of the initial context.

Conclusions

The four experiments presented in this article provide ample evidence for the reality of recognition without awareness; in this case, with words exposed for several seconds. In many ways the existence of the phenomenon is unsurprising as related effects have been reported over the years. One example is the ability of participants to make accurate psychophysical judgments (e.g., relative judgments of weight, length, and shape) while claiming that they were simply guessing (early studies reviewed by Adams, 1957). A second example is evidence for semantic processing of words in the absence of conscious identification of these words (e.g., Marcel, 1983; Stenberg, Lindgren, Johansson, Olsson & Rosén, 2000). In the present case we have suggested that variation in the strength of the effect is principally attributable to the general difficulty of the recognition decision in a particular experiment—easier decisions were associated with fewer guess responses but with higher values of recognition without awareness [higher values of $p(\mathrm{c})|0$]. The data are thus consistent with the notion that the subjective criterion for choosing correctly while stating that the choice was simply a guess is flexible, depending (among other possible factors) on the context of the overall recognition situation.

It may be asked what "criterion shift" means across different conditions that always involve the forced-choice procedure; does the participant not simply choose the subjectively strongest item in all cases? In answer, we emphasize that our use of the term "criterion shift" does not refer to whether or not participants make a choice—they choose on all trials—but rather to the subjective state accompanying the selection, and to the fact that this state varies as a function of overall task difficulty. Under easy conditions many trials yield obvious selections labeled 1 or 2. On the remaining trials participants can still select the correct item, but these cases feel relatively less obvious and are therefore labeled 0. Under difficult conditions participants make more "guess" selections, but in this case the general difficulty results in the selection of fewer target items; choice is much closer to chance responding.

Finally, unlike Voss and Paller (2009), we see no reason in our data to suggest that implicit and explicit recognition reflect different forms of memory. We argue rather that correct selection of a target item may be based on relative fluency of processing, or on the strength or adequacy of its encoded representation, and that these factors are likely to vary on a continuum. Additionally, however, the recognition process will evoke some representation of the item's previous context of occurrence. This representation will also vary in the degree to which it fully specifies the past event; inadequate representations may simply evoke a feeling of general "pastness" whereas more adequate representations will reinstate a conscious memory of the original event. In turn, these different degrees of adequacy will be associated, respectively, with the subjective impressions of familiarity and recollection. In cases where such additional contextual representations are not evoked, the participant may still choose the target item correctly, but now with no subjective feeling of explicit recognition. These cases may therefore be described as recognition without awareness.

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