01 Jan 1989

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Ronald Thomas Kellogg
Missouri University of Science and Technology

Ruth S. Dare

Bulletin of the Psychonomic Society
1989, 27 (5), 409-412

Explicit memory for unattended information

RONALD T. KELLOGG and RUTH S. DARE
University of Missouri-Rolla, Rolla, Missouri

Explicit recognition memory of unattended information was tested in two studies. College students performed complex mental addition problems in the presence of distracting words, with instructions to concentrate on rapidly and accurately verifying the accompanying arithmetic answers. Then, they took a surprise recognition test on the words. Experiment 1 showed that a short exposure (800 msec) resulted in chance levels of recognition performance, whereas a longer exposure (1,100 msec) supported recognition barely better than chance. Experiment 2 addressed whether attended and unattended encoding are qualitatively different mental states or instead the same state, differing only in the degree of attention given. A state-dependent memory effect was observed, in which reactivating the same attentional state at the time of test as had occurred at the time of study had beneficial effects on recognition performance. This outcome adds to other types of evidence, which suggest that attended and unattended encoding differ qualitatively. It was concluded that unattended encoding supports an impoverished degree of explicit, as well as implicit, long-term memory.

Studies of whether unattended material can later be recalled or recognized have led to mixed results and different conclusions. In some experiments, no retention on these explicit memory tests has been found, and it has therefore been concluded that attention is necessary for any long-term memory storage (Carlson & Dulany, 1985; Fisk & Schneider, 1984, Experiment 1; Moray, 1959). Others, who have found performance barely better than chance, have concluded that an impoverished representation of the material is stored even in the absence of attention (Kellogg, 1980, 1985). Finally, some also find recognition barely better than chance, but they presume that a slight degree of attention must have been given to the supposedly ignored material (Fisk & Schneider, 1984, Experiment 2; Wolford & Morrison, 1980).

In other studies, it has been reported that unattended material produces subtle but reliable effects on implicit memory tests that do not require awareness as a recognition test does (Eich, 1984; Miller, 1987). These results are consistent with the view that unattended encoding establishes a weak memory representation. Nevertheless, the differing results and conclusions from the studies of explicit memory are unsettling.

Experiment 1 was addressed to one factor, exposure duration, that may account partly for the differing results in the literature. Experiment 2 was addressed to whether attended and unattended encoding are qualitatively different from one another, or, alternatively, whether they are best viewed as the same mental state, differing only in the quantity of attention given. If they are qualitatively different, then one would expect to find state-dependent memory effects associated with these different mental states (Kellogg, Cocklin, & Bourne, 1982).

Correspondence may be addressed to Ronald T. Kellogg, Department of Psychology, University of Missouri-Rolla, Rolla, MO 65401-0249.

EXPERIMENT 1

A key difference between studies in which recognition above chance has been reported and studies in which no recognition has been found may lie in exposure duration. For example, Fisk and Schneider (1984) employed an exposure of 600 msec in Experiment 1, and 800 msec in Experiment 2. They found recognition above chance only in the latter. Both much shorter (Carlson & Dulany, 1985) and much longer (Kellogg, 1980) exposures have been studied. The critical exposure duration needed for unattended explicit memory probably depends on the context; the difficulty of the primary task designed to occupy the subject's attention, the list length, the type of materials, the frequency of presentation, and other well-known variables all presumably matter. Because the procedures of these studies differed in several ways besides exposure duration, an experiment in which only this factor is varied was needed.

Participants in the present experiment were led to believe that the study dealt with the effects of distraction on their ability to perform mental arithmetic. On each trial, an addition problem was presented with an answer. On the line between the problem and the answer was a to-be-ignored word that was visually registered by the participants as they carried out the addition problem. Their task was to look at the problem and verify, after either 800 or 1,100 msec, whether or not the answer was correct. Error-free performance, in the absence of distractors, takes about 1,900 msec for problems of the type employed here (Geary, Widaman, & Little, 1986). The attentional demands of the addition task, plus the instructions and brief presentation rate, were designed to prevent the subjects from attending to the words. Finally, a surprise recognition test was given on the words presented during the middle trial blocks; the first and last trial blocks were not tested, because they could have been tainted by failures of selective attention and recency effects (Fisk & Schneider, 1984).

Method

College students taking introductory psychology were randomly assigned in equal numbers to a short- or long-exposure condition (N = 32). They were instructed that the experiment concerned their ability to concentrate fully on performing mental addition in the presence of distracting information. A cover story was given that emphasized the importance of ignoring the distracting words and attending fully to the rapid calculation of a mental addition problem (after Kellogg, 1980). The subjects gave their consent to participate, and they were fully debriefed at the conclusion of the collection of data. They were tested in small groups (n = 1-4), seated 9-12 ft in front of a projection screen such that the stimuli subtended approximately the same visual angle for each subject.

On each trial, a blank slide was projected first, and the experimenter said the word "ready." Next, a complex addition problem, following the terminology of Geary et al. (1986), was presented. Below the addition line, a distracting word was inserted. Just below that, a sum was provided. The subject's task was to verify whether the provided answer was correct. Next, the screen went dark for two slide presentations, giving the subjects time to record their verification response (T for True or F for False) on an answer sheet. The experimenter said the word "answer" at the onset of the dark interval. The exposure was either short (800 msec) or long (1,100 msec) for each slide in the trial sequence.

First, the subjects received a block of practice problems to familiarize them with the task. Then, four blocks of 10 trials each were presented. A surprise recognition test was given next, which included only old items from the second and third blocks. Pilot testing indicated that it was critical that subjects be encouraged to search their memory carefully and perform as well as possible on the recognition test. Otherwise, they quickly became frustrated and gave up trying to remember. The test included 20 old and 20 new items, randomly intermixed. The subjects responded on a 6-point recognition scale ranging from −3 to +3 with zero excluded. Positive ratings were for old words and negative ratings for new words, with the absolute values of the ratings reflecting the subjects' confidence in the accuracy of their responses.

All the words were drawn from section 8 of the Colorado word norms (Toglia et al., 1978). They were common nouns, between 4 and 7 letters long, and they were equated in meaningfulness, familiarity, and several other attributes. Each addition problem, which consisted of two vertically placed double-digit integers with a stated sum, was used only once. Half were true and half false, randomly intermixed. The false problems were incorrect by plus or minus 1, 2, 10, or 20. All sums were less than 100; a carrying operation was never required on the first addend of each problem. The digits 0 and 1, double-digit numbers (e.g., 22), and repeated numbers (e.g., 45 + 45) were excluded in generating the problems.

Results

Recognition performance, indexed by d', was better in the long-duration condition (M = .35) than in the short-duration condition (M = −.17). An analysis of variance (ANOVA) indicated that this difference was reliable [$F(1,30) = 4.15$, $MS_e = .26$]. The significance level was set at $p < .05$ in all analyses reported here. Performance was better than chance only in the long-duration condition.

Mean recognition confidence ratings given to the old and new items are shown in Table 1. An ANOVA revealed a significant main effect of item type [$F(1,30 = 8.11$], and an interaction of item type × exposure duration [$F(1,30) = 4.61$, $MS_e = .21$] for both effects. Specific planned comparisons showed a reliable difference between old and new items only for subjects in the long-duration condition.

Table 1
Mean Recognition Confidence Ratings in Experiment 1

Condition	Item Type: Old	Item Type: New
Short exposure	.31	.23
Long exposure	.54	−.04

The overall mean proportion correct on the addition problems was .90 in the short- and .93 in the long-duration condition. The means did not differ reliably. The high levels of performance suggest that the subjects concentrated on the addition task. Also, the correlation between primary task performance and d' in the short ($r = -.19$) and long conditions ($r = .15$) was not significantly different from zero (overall $r = .06$). A significant negative correlation would have indicated that subjects attended to the secondary words at the expense of the primary task.

EXPERIMENT 2

One interpretation of Experiment 1 is that a sufficient exposure to unattended information results in a very slight degree of explicit memory. An alternative interpretation is that the long exposure allowed the subjects to attend to the words as well as perform the mental addition. Although previous work had shown that accurate performance on the addition task used here required more time than we allowed (Geary et al., 1986), it was important to test this possibility directly.

The rationale adopted here was to assess whether attended and unattended encoding differ qualitatively or merely in the quantity of attention allocated. Many theorists have suggested that attentional processes differ qualitatively from those operating without attention, in terms of capacity limitations, automaticity, and awareness (e.g., Posner & Snyder, 1975). Kellogg (1980) reported evidence that attended and unattended encoding differed on all three dimensions. These qualitative differences appeared to rule out the possibility that the two cases differed merely in the quantity of attention allocated. As Fisk and Schneider (1984) have noted, however, the use of insensitive measures could lead one to incorrectly conclude that there are qualitative differences.

For example, to determine whether unattended encoding occurs without drawing on limited attentional capacity, one can assess interference on primary task performance. If mental addition accuracy suffers when distracting words are present, relative to a control condition in which the addition is performed without distractors, then it should be clear that some attention has been devoted to the words. Lack of interference may imply either that the words did not draw on limited attentional capacity or that the accuracy measure was too insensitive to detect brief allocations of attention.

The literature on state-dependent memory suggests an alternative way of demonstrating qualitative differences between attended and unattended encoding. If these attentional states are qualitatively different, then one would expect to find state-dependent memory effects associated with them (Kellogg et al., 1982). Following unattended encoding, one would expect that attempts to reactivate the unattended encoding, involving repetition of the primary addition task just prior to a recognition judgment, would have a beneficial effect on recognition. Following attended encoding, such a procedure should have a detrimental effect.

Kellogg et al. (1982) failed to find attentional state dependencies. Experiment 2 differed from that work in that here exactly the same arithmetic problem was repeated at the time of test in order to reactivate the encoding conditions. In Kellogg et al.'s (1982) study, a problem of similar but not identical difficulty was repeated at test. The use of identical problems may be a critical factor in observing attentional state dependency.

Method

The subject pool (N = 64) and basic procedures from Experiment 1 were again used. A 2 × 2 factorial design was employed, with study state (attended or unattended) and test state (attended or unattended) as factors. A fifth control condition was also tested: the control subjects performed the primary addition task without distracting words. The unattended study state replicated Experiment 1. The attended study state was an intentional learning task. The subjects were instructed to attend to a series of words with the intention of remembering them as well as possible. The attended test state was a replication of the standard recognition test given in Experiment 1. Finally, the unattended test state was a modified recognition test designed to activate or reactivate, depending on the condition, unattended encoding processes just prior to making a recognition judgment.

The modified test began with an addition problem and a distracting word. The same addition problems were presented again in a different random order. Half of the original distracting words (those from blocks two and three) were presented again with the same problem as before, and the other problems were paired with new distracting words. After the subject had performed the verification task on each trial, a blank slide was presented and the experimenter said the word "recognize." Then, the distracting word was again presented in isolation. The subject decided whether it was old, a word that occurred during the initial study phase of the experiment, or new. Finally, the screen went dark for two slide presentations to allow time to record the recognition rating on the answer sheet (as in Experiment 1). The exposure duration was 1,100 msec for each slide presentation in the trial sequence.

Results

Recognition performance (d') is shown in Figure 1. An ANOVA indicated significant main effects of study state [$F(1,60)$ = 100.19] and test state [$F(1,60)$ = 8.60], and a significant interaction of study × test states [$F(1,60)$ = 11.03, MS_e = .47] in all cases. The interaction represents an asymmetric form of state-dependent memory. Activating unattended encoding operations at test markedly hindered recognition performance for subjects who attended to the words during study. Reactivating these operations at test for those who initially encoded the words without attention, if anything, slightly improved recognition. The effect is asymmetric, in that performance was not substantially better in the unattended/unattended condition relative to the unattended/attended condition.

It might be argued that the interaction arose because of a floor effect in the unattended conditions. But this is a weak argument, given that recognition performance was

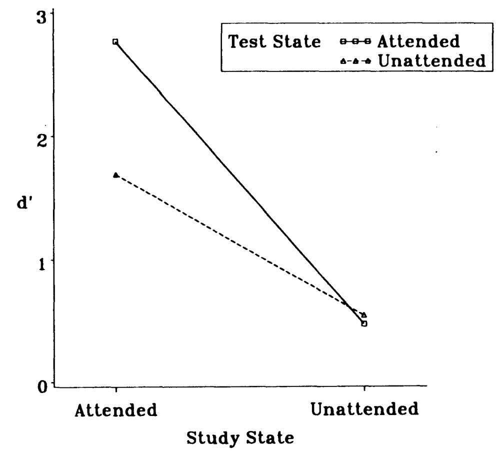

Figure 1. Mean recognition performance (d') in Experiment 2.

significantly greater than zero. There was room for d' to drop to zero in the unattended/unattended condition, eliminating the interaction of study state and test state. This did not occur; the results are best viewed as an asymmetric state dependency.

Mean recognition-confidence ratings for old and new items are given in Table 2. An ANOVA showed a main effect of item type [$F(1,60)$ = 439.03], and three interactions; item type × study state [$F(1,60)$ = 193.95], item type × test state [$F(1,60)$ = 10.57], and item type × study state × test state [$F(1,60)$ = 13.0; MS_e = .35 for all effects]. No other effects were significant. Replicating the results in Experiment 1, unattended encoding supported a very weak but reliable level of discrimination between old (M = .55) and new (M = −.18) items. Attended encoding supported much better discrimination between old (M = 1.93) and new (M = −1.71) items.

The mean accuracy on the addition task during the study phase was .95, .96, and .94 for the unattended/attended, unattended/unattended, and control conditions, respectively. An ANOVA showed no differences. On problems during the test phase, mean accuracy was slightly greater in the control condition (M = .96) than in the unattended/unattended condition (M = .91), with the attended/unattended condition (M = .93) falling in between. An ANOVA showed a significant main effect of this variable [$F(2,45)$ = 3.72, MS_e = .003].

Such interference suggests that the subjects had some trouble concentrating completely on the addition problems

Table 2
Mean Recognition Confidence Ratings in Experiment 2

Study Condition	Item Type: Old	Item Type: New
Attended Test		
Attended	2.32	−2.05
Unattended	.35	−.34
Unattended Test		
Attended	1.55	−1.38
Unattended	.75	−.03

during the recognition test. This may have weakened the strength of the state-dependent memory effect by not fully reactivating the unattended encoding state. Also, note that the accuracy measure was apparently sensitive enough to detect shifts of attention from the primary addition task. The null result of no interference during study trials, therefore, cannot be attributed to an insensitive measure.

Another indication that subjects did not attend to the words during the study phase in the unattended encoding conditions was the lack of a negative correlation between primary task performance and d' (overall $r = .04$). The correlations were not significantly different from zero in both the unattended/attended ($r = -.06$) and the unattended/unattended ($r = .12$) conditions.

GENERAL DISCUSSION

Experiment 1 established exposure duration as a critical factor for determining whether unattended encoding supports a detectable degree of long-term recognition memory. The precise duration needed undoubtedly depends on the context of the experiment.

To argue that the subjects with the longer exposure must have attended briefly to the to-be-ignored material begs the question of whether attention is necessary for explicit memory. Experiment 2 suggested that attended and unattended encoding differ qualitatively in that they are susceptible to a state-dependent memory effect. As is often seen with other such effects (Eich, 1977), there was an asymmetry observed here. Activating unattended encoding operations at test following attended encoding at study was far more detrimental than activating attended encoding following unattended encoding at study. This outcome implies an important role for full attention at the time of retrieving information from long-term memory. Just as full attention is important for encoding, it also appears important for retrieval.

No one questions that attention—particularly in the form of elaborative rehearsal—is necessary for robust memory. However, there are several reasons for doubting that attention is necessary for the formation of very weak memorial representations. First, there appear to be several qualitative differences between attended and unattended encoding that cannot easily be accounted for by assuming that these two situations differ only in the quantity of attention given (Kellogg, 1980).

Second, other studies indicate that unattended material is certainly processed at the level of perceptual (Broadbent, 1958; Moray, 1959) and possibly semantic features (Marcel, 1983). Although this processing appears to be impoverished, it certainly should leave an equally impoverished memory representation, assuming the general notion that memory is best viewed as a record of encoding operations (Craik & Lockhart, 1972; Kolers & Roediger, 1984).

Third, unattended processing leaves a durable enough record to result in performance above chance on implicit long-term memory tests (Eich, 1984), and on explicit short-term (30 sec or less) memory tests (Norman, 1969), even when explicit long-term memory tests fail to detect recognition above chance. Finally, the present findings plus other experiments cited earlier (Fisk & Schneider, Experiment 2, 1984) indicate that it is possible to design an experiment sensitive enough to detect recognition that is barely above chance on a long-term explicit memory test.

The conclusion that attention is not necessary for very poor memory is of theoretical interest. But it does not imply that unattended encoding has any practical value in, say, subliminal learning or persuasion technology. The degree of elaboration resulting from unattended encoding appears to be too limited to have any substantive influence on human cognition or behavior.

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(Manuscript received February 15, 1989.)