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Psychophysiological indices of implicit memory performance

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Skin conduction responses (SCRs) and event-related brain potentials (ERPs) are shown to be sensitive indicators of a memory trace in both implicit and explicit tests of memory. In several explicit recognition tasks, the amplitude of both ERPs and SCRs was higher for new than for repeated words, regardless of whether the subjects recognized or missed the old words. In implicit tasks in which reaction times and ERPs were recorded concurrently, categorical decisions were faster with studied than with new words, but the magnitude of the repetition effect did not vary with the number of repetitions or with the elapsed time since the last repetition. In contrast, ERPs were sensitive to both variables, suggesting that ERPs may be correlated with the memory strength of a trace.

The current psychological literature distinguishes between two broad classes of memory tests: explicit and implicit (Graf & Schacter, 1985; for reviews, see Richardson-Klavehn & Bjork, 1988, and Schacter, 1987). Explicit memory tests, such as tests of recall or recognition, require conscious recollection of the events in question. Implicit memory tests do not require conscious reference to past experience, but instead assess memory by measuring the effects of that experience on subsequent performance on tasks such as lexical decision (Smith, MacLeod, Bain, & Hoppe, 1989), word-fragment completion (Tulving, Schacter, & Stark, 1982), or perceptual identification (Jacoby & Hayman, 1987). Thus, a subject's ability to read or identify previously studied words has been found to improve even though he or she may not explicitly remember having studied them. Indeed memory for an item on one test may or may not be predictive of memory for the identical item on another (Hayman & Tulving, 1989; Jacoby & Witherspoon, 1982; Mitchell & Brown, 1988). The dissociation between performance on the two types of memory tests can be seen most dramatically in amnesic patients whose memory is found to be significantly impaired or even absent when tested explicitly, yet whose memory appears to be normal when tested implicitly (Diamond & Rozin, 1984; Graf & Schacter, 1985; Graf, Squire, & Mandler, 1984; Rozin, 1976; Warrington & Weiskrantz, 1974, 1978).

To date, almost all of the research on the distinction between implicit and explicit tests of memory has involved behavioral measures such as reaction time (RT) and accuracy. We wish to present some studies of memory that involve skin conductive responses (SCRs) and event-related brain potentials (ERPs), not simply to add variety, but because we believe that electrophysiological measures may provide information about the processes and mechanisms that mediate performance on explicit and implicit tests of memory.

There is already an extensive literature on SCRs—or what used to be called the galvanic skin response (GSR)—and memory (Craik & Blankstein, 1975), and some literature on ERPs and memory (Kutas, 1988). With few exceptions, this literature is concerned with explicit tests of memory. Our first purpose in the studies we report, then, was to demonstrate that electrophysiological responses to repeated events can also serve as an implicit test of memory. Having shown that, our second purpose was to study the relationship between electrophysiological measures and more traditional behavioral measures of performance on memory tests. Such studies, we hope, will reveal the potentially unique contributions that electrophysiological data can make to research on memory.

Our research on SCRs and memory was based more on intuition than on a compelling rationale. The study was part of Mary Rees-Nishio's doctoral dissertation at the University of Toronto (1984; cited in Moscovitch, 1985). Rees-Nishio was interested in studying the relation between emotion and memory, and she chose to examine the SCR because it is known to be a sensitive index of

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emotional responsiveness to words. The SCR, we conjectured, might also be a sensitive measure of performance on implicit tests of memory. The SCR had had a long and checkered past as a tool for studying perception without awareness (Eriksen, 1960; Dixon, 1971), and we thought that it would be worth the risk to use it as a tool for studying memory without awareness. Would the SCR be a sensitive index of information stored in memory even when the subject explicitly denied remembering the target event?

To answer the above question, yet still examine the relation between emotion and memory, Rees-Nishio and Moscovitch designed the following study (Moscovitch, 1985). Subjects studied a mixed list of 30 neutral and 30 emotional, often obscene, words, one at a time. One week later, they read a new list containing 30 emotional and 30 neutral words. In the new list, 15 words of each type were *old* words that they had studied previously, and 15 were *new* words. The subjects were instructed to indicate after reading each word whether it was old or new and to rate the confidence they had in their answer on a scale from 1 to 7, with 1 standing for low confidence and 7 high. The words in the study and test sessions were presented at a rate of 1 every 30 sec.

The palmar SCR was recorded continuously throughout both sessions with two electrodes placed on the left palm near the thumb and the index finger (thenar and hypothenar eminences). The SCR data of interest are the differences in micromhos between the prestimulus SCR level and the first peak poststimulus SCR occurring within 8 sec of stimulus presentation. Twenty young undergraduates at the University of Toronto and 25 elderly subjects, with mean ages of 20.5 and 69 years, respectively, participated in the study.

A number of interesting results emerged from this study, but only those most relevant to our concerns in this presentation will be reported here. Because different emotional words were presented to the young and elderly subjects, the results of the two groups were analyzed separately. First, t tests showed that memory as measured by d' was greater for emotional than for neutral words, the values being 1.88 as opposed to 1.03 for the young ($p < .01$), and 1.17 as opposed to 0.94 for the elderly ($p < .24$). Analysis of variance (henceforth ANOVA; emotionality $\times$ old/new judgments $\times$ previous occurrence) showed that the confidence ratings were also higher for emotional than for neutral words, 5.43 as opposed to 4.93 for the young ($p < .01$), and 5.05 as opposed to 4.61 for the elderly ($p < .001$). As might also have been expected, the SCR at test was higher for emotional than for neutral words, 1.21 as opposed to 1.02 micromhos for the young ($p < .01$), and 0.79 as opposed to 0.75 micromhos for the elderly ($p > .1$).

Most importantly, given the topic of this symposium, the SCR was higher with old than with new words, regardless of the subjects' judgments as to whether the words were old or new and regardless of the confidence they had in those judgments. This effect was especially noticeable with the emotional words, but the effects were discernible for the neutral words as well. For young people, the SCRs in micromhos to hits and misses (old words) were 1.23 and 1.27 when the words were emotional, and 1.10 and 1.02 when the words were neutral. The SCRs in response to correct rejections and false alarms (new words) were 1.16 and 1.17 for emotional words and 0.96 and 1.00 for neutral words. The comparable figures for the elderly subjects were as follows: For hits and misses, the SCRs were 0.85 and 0.80 for emotional words and 0.85 and 0.72 for neutral words. For correct rejections and false alarms, the SCRs were 0.73 and 0.76 for emotional words, and 0.70 and 0.75 for neutral words. The ANOVA confirmed that the SCR was greater with old than with new words, both in the young ($p < .01$) and in the elderly ($p < .02$) subjects.

The finding that SCR was higher with old than with new words even when recognition was erroneous indicates that SCR can serve as a useful implicit measure of memory. The typical objection that SCR, being a continuous measure, is a more sensitive index of memory than recognition, which is discrete, is not valid in this case. Confidence ratings are also continuous, yet SCRs do not coincide with them either. Confidence ratings were higher with respect to correct as opposed to incorrect judgments (see Moscovitch, 1985), whereas SCRs were higher with old than with new words, whether they were correct or not. The conclusion we draw from these results is that SCR modulated by neurocognitive processes associated with the repetition of a previous event, regardless of whether or not those processes could support an explicit memory for that event. This finding encouraged us to examine whether another electrophysiological measure, ERPs, would behave in a comparable fashion.

ERPs represent changes in transmembrane currents in active neural tissue that are time-locked to a stimulus event. Because transmembrane currents are volume-conducted instantaneously throughout a conductive medium, ERPs can be recorded at the scalp. Some ERPs reflect the operation of cognitive processes engendered by the stimulus in the context of the subject's task (for a review, see Donchin, Ritter, & McCallum, 1978). In contrast to most behavioral measures, which are discrete and delayed relative to the process under investigation, the brain waves are sampled continuously, and they therefore provide an immediate and continuous record of brain activity associated with the presentation of a stimulus. In this sense, they are also superior to the SCR, which, though continuous, is generated even more slowly than the behavioral response, often lagging behind it by seconds. The latency to one ERP (generically labeled P300) has been shown to reflect the time required by the system for stimulus evaluation, but it is not sensitive to response selection processes (McCarthy & Donchin, 1981). Another ERP (N400) is modulated by semantic priming (Bentin, McCarthy, & Wood, 1985; Kutas & Hillyard, 1984) and presumably reflects the encoding of words in the lexicon (Bentin, 1987). These ERPs have been used successfully to predict stimulus recognition (Fabiani, Karis, & Donchin, 1986; Paller, Kutas, & Mayes, 1987; Paller, McCarthy, & Wood, 1988), and they are sensitive to the repetition effect (Bentin & McCarthy, 1990; Bentin & Peled, in press; Nagy & Rugg, 1989; Rugg, 1985, 1987).

A central concern in memory research is whether performance on implicit and explicit tests of memory is mediated by two functionally distinct systems that encode separate traces of the event (e.g., Cohen & Squire, 1980; Hayman & Tulving, 1989; Mandler, 1980; Mitchell & Brown, 1988; Squire & Cohen, 1984; Tulving, 1985), or whether performance on both types of tests is mediated by a common trace that is accessible by different routes or mnemonic strategies, some of which are more suitable than others for inducing awareness of the memory trace (Jacoby, 1983; Moscovitch & Umiltà, in press; Roediger & Blaxton, 1987; Witherspoon & Moscovitch, 1989).

The various interpretations of the many dissociations found between performance on implicit and performance on explicit memory tests (Schacter, 1987) have been based on behavioral measures such as accuracy and RT. These data may be complemented with ERP measures of memory to provide a better insight into the cognitive mechanism that mediates performance on the two types of tests. Consequently, we used ERPs in conjunction with accuracy and RTs in implicit and explicit tests of memory.

The experiments consisted of three consecutive phases: a study phase, an explicit test, and an implicit test. In the study phase, subjects had to make rapid categorical decisions about stimuli presented in sequence. In the explicit test, recognition of words presented in the study phase was assessed by having subjects indicate whether words were old studied words or new words that had not been studied. The implicit test that followed was a categorical decision task similar to the one in the study phase. Some of the words encountered in the implicit test were words that appeared in the study and in the recognition phases; others were words that appeared only at recognition; and some were new words. RTs, accuracy, and ERPs were measured in all phases of the experiment. Improved performance elicited by old words as opposed to new words as reflected in shorter RTs is a measure of implicit memory or savings of the previously experienced items, because the subject is not required to reflect on the past in order to perform the task. Indeed, amnesic patients who cannot even remember studying the words nonetheless show normal repetition priming effects on similar tasks (Moscovitch, 1985).

The first set of ERP data that we present was obtained with two groups of subjects, each tested with a different categorical decision. One group was tested on a semantic decision task (animate or inanimate), and the other group was tested on a lexical decision task. Because the design used for both tasks was identical and the results were very similar, we will present them in parallel.

Thirty-two undergraduates (14 males) at the Hebrew University who were native Hebrew speakers participated in the experiment. Half were tested in the semantic decision condition, and the other half in the lexical decision condition.

In the semantic decision task, 64 words were presented in the study phase. All 64 words were again presented in the recognition test, together with 128 lures. In the implicit test that followed, the 64 words that were originally studied were repeated yet again, together with 48 words randomly selected from the set of lures in the recognition test and 48 new words. In each phase and within each set, half the words signified animate objects and half signified inanimate objects.

In the lexical decision task, the study phase included 48 words and 48 nonwords. All 48 words were presented in the recognition test, together with 96 lures. In the implicit test, the 48 studied words were repeated again, together with 24 lures from the recognition test and 24 new words. The nonwords in the implicit test were the 48 nonwords originally used during study and 48 new nonwords. The rated word frequency was average and equal in the different word groups. The nonwords were phonologically legal but meaningless. All stimuli were Hebrew words that were computer-generated on a CRT from a standard set of Hebrew characters without the vowel dots.

EEG was recorded with Grass silver electrodes from nine scalp sites (F3, Fz, F4, Cz, P3, Pz, P4, and two temporal sites, one of them halfway between T3 and T5 [T3/5] and one halfway between T4 and T6 [T4/6]; 10-20 system). Linked ears were used as the reference. Eye movements (EOG) were recorded bipolarly between an electrode placed on the external canthus of the left eye and an electrode placed on the supraorbital ridge, just above the center of the left eyebrow. EEG and EOG were amplified by Grass J511 amplifiers through a bandpass of 0.1-100 Hz (3 dB/octave), and sampled on-line at a rate of 250 Hz for 1,024 msec. Sampling started 100 msec before stimulus onset. Single-trial data were stored on disk, and averaged off-line.

The experiments were run in an electrically isolated and acoustically treated chamber that was dimly lit. The stimuli were presented for 1,000 msec each, and separated by a 2,500-msec interstimulus interval. The same exposure time and rate of presentation was used throughout the experiment. The study phase began with 16 practice stimuli, which were followed by the test stimuli presented in one block. The subjects pressed one of two microswitches, as quickly and accurately as possible, to distinguish between the words for animate and the words for inanimate objects in the semantic condition and between words and nonwords in the lexical decision condition. Different hands were used for each response type.

At the end of the study phase, after an intermission of 5 min, the explicit recognition test began. The subjects were instructed to distinguish between old and new words, presented in one uninterrupted sequence. They responded by pressing one of the two microswitch buttons as quickly and accurately as they could. Finally, following the explicit test of memory and an additional 5-min intermission, the categorical decision test was repeated, providing an implicit measure of memory. Thus, repetitions occurred at a lag of about 40 min, with more than 200 intervening stimuli.

We will report first the behavioral data. The level of explicit recognition was similar for the two tasks. The d' was 1.77 following the semantic decision task and 1.76 following the lexical decision task. Each subject's RTs were averaged separately for the four possible outcomes: hit (H), miss (M), correct rejection (CR), and false alarm (FA). RTs to correct responses in the semantic decision task (H = 804 and CR = 825) were faster than RTs to incorrect responses (M = 925 and FA = 908, $p < .001$). The same was true of the lexical decision task, the values being H = 735, CR = 769, M = 862, and FA = 869 ($p < .001$). On the other hand, in both the semantic and the lexical decision tasks, the RTs to repeated stimuli, H and M, were not significantly different from the RTs to new stimuli, CR and FA; nor was the interaction between repetition and response accuracy effects significant.

The general pattern of the ERPs elicited by words was similar in each of the four outcome conditions of the recognition task. The most conspicuous aspect in the waveforms was a late positive potential. This potential was considered to be P300 because it was bigger at the central and parietal sites than at any other site, and because it was elicited in a categorical decision task. In the present experiment, we focused on repetition effects. Therefore, the ERPs elicited by old items, H and M, were collapsed into one average, as was done for the ERPs for responses to new items. Comparison of the averaged ERPs elicited by old and new words revealed a clear repetition effect (see Figure 1). Because the number of incorrect responses was too small, we could not reliably compare the ERPs elicited by correct and incorrect responses. However, the general trend of this comparison conformed with expectations: The peak latency of the P300 was smaller for correct than for incorrect responses.

The P300 elicited by repeated stimuli was more positive than that elicited by new stimuli. The divergence between the two waveforms started at about 450 msec from stimulus onset when recognition followed the semantic decision task, and at about 250 msec when it followed the lexical decision task. In both groups, the maximum difference was at about 600 msec, at the peak of the P300 elicited by repetitions. For statistical evaluation of the ERP repetition effects, we calculated the mean amplitude of the waveforms elicited in each condition, during an epoch starting 64 msec before and ending 64 msec after the latency of the P300 peak in each condition. Mean rather than maximum amplitudes were used to control for random variability at one sampling point.

An ANOVA with repeated measures was performed on the mean amplitude measures, separately in each group. The factors were repetition (repeated vs. new stimuli) and electrode site (F3, Fz, F4, T3/5, Cz, T4/6, P3, Pz, P4). The degrees of freedom were adjusted wherever necessary, according to the Greenhouse-Geisser procedure to

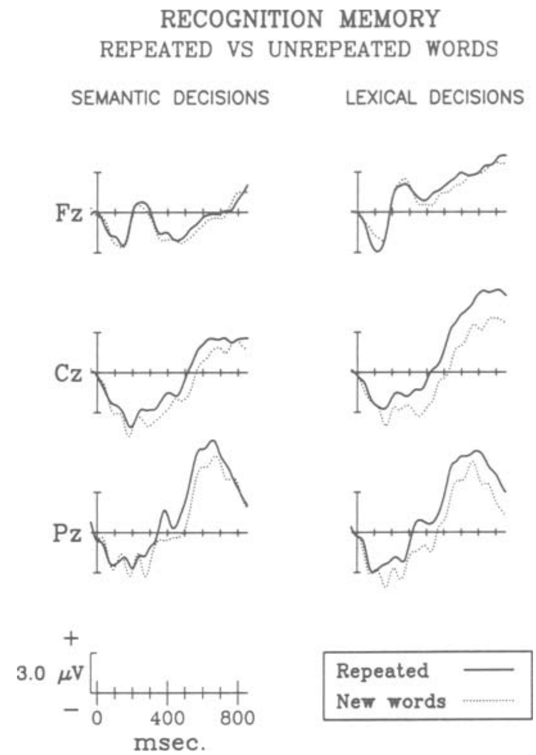

Figure 1. ERPs elicited by repeated and unrepeated words presented in the explicit memory task.

control for Type I error in repeated-measures designs. The ANOVA showed significant main effects of both repetition ($p < .05$) and electrode site ($p < .05$). Post hoc Tukey-A comparisons showed that the amplitudes at Pz and Cz were higher than at any other site.

Let us turn now to the results of the implicit memory test. The RTs to words in the second categorical decision task were averaged according to five conditions. Three consisted of repeated items: (1) words that were presented in the study phase and categorized as *old* during the explicit recognition test (HE); (2) words that were presented in the study phase and categorized as *new* during the explicit recognition test (ME); and (3) words that were new in the explicit recognition test, and were correctly rejected (CRE). Two consisted of nonrepeated items: (4) the original presentation of the target stimuli during the study phase (NS); and (5) new words—that is, words that were presented in the implicit phase for the first time (NI). The differences between the RTs for these conditions were analyzed with a one-way ANOVA, which was followed by post hoc Tukey-A comparisons. Semantic decisions in response to repeated words (HE = 647, ME = 620, and CRE = 666) were on the average significantly faster than to nonrepeated words (NS = 680 and NI = 708, $p < .001$). Similarly, lexical decisions in response to repeated words (H = 557, ME = 552, and CRE = 557) were faster than to nonrepeated words (NS = 586 and NI = 593, $p < .001$). Comparisons of individual conditions showed that RTs to new words were longer than to any of the repeated words. The apparent difference between the different groups of repeated words in the semantic decision task was not statistically significant.

As in the recognition memory task, the ERPs recorded during the implicit testing of memory were similar in the semantic decision and lexical decision tasks. Throughout the study, the late positive potential that we identified as P300 was the most conspicuous component in the waveforms. The amplitudes of this component were very similar in the *HE* and *ME* conditions. Relative to these two groups of repeated stimuli, the P300 elicited by new stimuli was considerably smaller. The amplitude of P300 elicited by words that were repeated only once (*CRE*) was smaller than that elicited by stimuli that were repeated twice, but bigger than the P300 elicited by new stimuli.

The statistical analysis of the repetition effects compared mean amplitudes of the P300 calculated for an epoch of 128 msec symmetrically located around the latency of the peak amplitude in each condition. The ANOVA revealed that the repetition effect was significant ($p < .01$).

The behavioral measures of performance on the implicit and explicit tests are consistent with those obtained in other studies. We will deal with the explicit tests first. The d' was similar to that obtained by the undergraduates in the SCR study. RTs, like confidence ratings in the SCR study, were shorter to correct than to incorrect responses, indicating that continuous measures of recognition, be they confidence ratings or RTs, parallel the discrete accuracy measures. Neither behavioral measure yielded significant effects of repetition that were independent of accuracy.

On the other hand, the ERP measures, like the SCR measures in the previous study, did produce significant repetition effects. The amplitude of the P300 was greater for repeated than for nonrepeated words, irrespective of the subjects' recognition of the items. Thus, concurrent recordings of electrophysiological responses during explicit memory tests can provide information about the retention of unremembered events. In short, by combining psychophysiological with behavioral responses, one can concurrently test memory explicitly and implicitly.

In the implicit tests, RTs were shorter to repeated than to nonrepeated words and were uninfluenced by the prior recognition of the word as old or new. Here too, the ERP measures provide a richer index of the prior history of the item than do the behavioral data. Whereas RTs yielded no significant differences between words that were repeated once or twice, the amplitude of P300 elicited by words that were repeated twice was higher, suggesting that ERPs may reflect the strength of the memory trace. This idea was pursued in a subsequent experiment.

The basic assumption in this experiment was that if the ERP amplitude is sensitive to the presumed strength of the memory trace, then to reduce d' should also reduce the amplitude of the ERPs elicited by repeated words. In this experiment, d' was reduced by increasing the delay between study and test and by interpolating an interfering task between them. The predicted effect on ERPs was observed.

The design of this experiment was identical to that of the previous one except for the following: Twenty-four undergraduates participated in the study. Only a lexical decision task was used. In the study phase, 120 words and 120 pronounceable nonwords were presented. Following the study phase, a subsidiary verbal task was presented that was unrelated to the experiment and lasted about 20 min. The explicit recognition test was administered after the subsidiary task. In the recognition list, there were 40 words randomly selected from those presented at study and 80 new words that were intermixed with the studied words. The implicit test that followed was a lexical decision task similar to the one in the study phase. There were 120 words and 120 nonwords in the implicit test, consisting of 40 words that were presented during the study phase but not in the recognition test, 24 words that were presented at both study and recognition, 24 words that were presented only at recognition, and 32 new words.

In the explicit recognition test, $d' = 0.86$, a significant reduction from a value of 1.76 in the previous study. As in the previous experiment, RTs in milliseconds for correct responses ($H = 796$ and $CR = 833$) were shorter than for incorrect responses ($M = 891$ and $FA = 868$, $p < .001$). As in Experiment 2, no significant repetition effect was found.

The ERPs in the recognition task did yield a significant repetition effect at central and parietal leads. Especially at the vertex, ERPs were significantly more positive for responses to *M* as opposed to *CR* and for responses to *H* as opposed to *FA* during a time epoch that began at about 350 msec and ended at about 700 msec from stimulus onset. The significant main effect of repetition ($p < .02$) interacted with electrode site ($p < .007$).

In the implicit test, RT in milliseconds to new words was 615, whereas RTs to repeated words were 568 msec for those presented only at study, 577 msec for those correctly rejected at recognition, and 564 msec for those presented twice, at study and again at recognition. RTs to repeated words were significantly shorter than to nonrepeated words ($p < .001$). Tukey-*A* post hoc test showed that the RTs to new words were not different from 592, the initial RT to words in the study phase. The magnitude of the repetition effect was similar for all repeated categories, indicating that RTs were sensitive only to the previous repetition and not to whether or not the item was recognized correctly, or to how often or how recently it appeared.

The ERPs elicited by repeated items were significantly more positive than those elicited by new items at all electrode sites ($p < .05$). However, in contrast to the RT effect, the magnitude of the ERP repetition effect varied with the presumed strength or accessibility of the memory traces. The difference between the ERPs elicited by repeated words and those elicited by new words was bigger for words whose initial presentation was more recent with respect to the repetition (words seen in the explicit test), and biggest for words that were repeated twice (Figure 2).

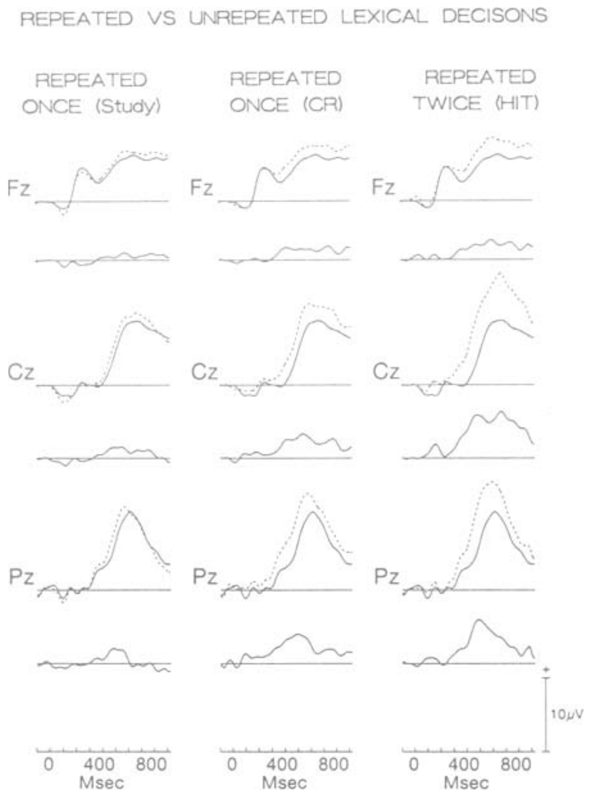

Figure 2. ERPs elicited by unrepeated items and by items repeated once or twice in the implicit memory test. The between-conditions difference waveforms reflect the repetition effect.

The ERPs elicited by words that were missed in the recognition tasks were almost identical, in the implicit test, to the ERPs elicited by words that were explicitly remembered.

The results of the third experiment show that the amplitudes of late ERPs are related to performance on both implicit and explicit tests of memory. On explicit recognition, the amplitude of the ERP varies with d', yet it still is sensitive to the actual repetition of a word even when the subject fails to recognize it. Thus, in agreement with previous studies of repetition effects, ERPs were more positive when elicited by old rather than new words (Bentin & Peled, in press; Rugg, 1987). Additional evidence for the sensitivity of ERPs to explicit memory can also be found in studies that show that ERPs elicited during study were predictive of subsequent memory performance (Fabiani et al., 1986; Karis, Fabiani, & Donchin, 1984; Neville, Kutas, Chesney, & Schmidt, 1986; Paller et al., 1987; Paller et al., 1988). These results also confirm the finding in the second experiment that ERPs are sensitive to the actual repetition of an item regardless of the subject's explicit recognition that the item is being repeated. In this regard, the ERPs resemble other indices of implicit tests of memory, except that they can also serve as that type of index concurrently with the subject's participation in an explicit test.

On implicit tests, ERP amplitude is higher for responses to repeated as opposed to nonrepeated words, an effect that is congruent with RT measures of repetition priming. Unlike RT, however, ERPs could distinguish between words presented once or twice, and between words presented near or far from the testing time. These results are consistent with the idea that ERPs are sensitive to the presumed strength of the memory trace, although alternative interpretations are certainly not excluded. For the moment, we are satisfied in having shown that ERPs provide a rich source of information that can complement behavioral measures on implicit and explicit tests of memory.

In conclusion, we suggest the following account of the memory events that are reflected by the data in our study. Presentation of an item leaves a memory trace that facilitates encoding of that item when it is repeated—a process that is reflected in the SCR, but especially in the ERP repetition effects on both implicit and explicit tests of memory. The ERP (and the SCR) amplitude was greater for responses to repeated than for responses to new items, but the size of the difference varied with the strength of the memory trace (as determined by how often or how recently an item was repeated). The underlying trace also accounts for the faster RTs with repetition on implicit tests of memory. It also can be shown to influence performance on explicit tests of memory if a continuous measure such as RT is used, rather than discrete old-new decisions. RTs to misses (items that have been previously studied but are judged to be new by the subject) were significantly longer than those to correct rejections, and the RTs to false alarms were significantly longer than were those to hits. This difference indicates that although both types of words were classified as new, the memory trace associated with misses, though not consciously apprehended, nonetheless influenced the latency of the decision. Thus, the ERPs seem to reflect the operation of processes common to both explicit and implicit tests of memory.

A possible interpretation of our findings is that the ERPs are related to the presumed strength or accessibility of memory traces in repetition effects. Such an interpretation would be consistent with the view that performance on both implicit and explicit tests of memory is influenced by a common trace that may be tapped at different levels of awareness as determined by the demand characteristics of the task and the retrieval operation they induce. Alternatively, it may be the case that separate traces may mediate performance on the two tests, but that the two (or more) traces are reactivated by the stimulus and jointly and concurrently influence the ERP. No definitive conclusion is warranted by our findings. We believe, however, that we have accomplished our primary objective: to demonstrate that psychophysiological measures provide a rich and unique source of information for investigators interested in implicit and explicit tests of memory.

The potential of SCR and ERP techniques waits to be exploited.

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