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REMEMBERING EMOTIONAL WORDS:

THE INFLUENCE OF CONTENT AND CONTEXT IN MEMORY ATTRIBUTION

by

Heather E. McNeely

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presented to the University of Waterloo

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Remembering Emotional Words:

The Influence of Content and Context in Memory Attribution

Abstract

The goal of this series of studies was to determine if neurophysiological reactivity to emotionality would be misinterpreted as a feeling of familiarity when encountered during a source monitoring task. Reactivity was expected to increase frequency of source errors, as well as increase amplitude of the late positive component (LPC) of the event-related potential (ERP), for emotionally salient new words. A large body of ERP and memory literature was replicated. In addition, the anticipated results of emotionality were found in two experiments. Behaviourally, emotionally salient new words were more likely to be mistakenly "recognized" at test than were either new neutral words or new words belonging to a non-emotional category, animal words. This effect was also noted electrophysiologically. Emotionality elicited a generally distributed positivity that began early and was maintained over the entire recording epoch. In contrast, ERPs to previously studied words were positive during the LPC and declined dramatically into a late negativity. ERPs to animal words were predominantly negative with a brief posterior positivity during the LPC. These findings indicate that word emotionality is a potent source of salience, having an impact on behavioural and electrophysiological response distinct from the effect of previous occurrence and also distinct from a categorical effect. It was anticipated that even greater reactivity to emotional salience would be observed in older adults, as decreased attentional capacity due to aging would make older adults more vulnerable to the influence of automatic sources of salience. However, in experiment three, older adults exhibited increased frequency of source errors and increased LPC

amplitude, not to emotionality, but to new animal words. These findings have important implications for understanding memory attributions, and suggest that the LPC may not reflect recollective processes *per se*, as is the current interpretation in the literature. Rather, the LPC may more aptly be considered an index of relative stimulus salience. The present findings indicate that what captures attention and determines relative stimulus salience depends on the goals of the individual as well as the context in which information is encountered.

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General Introduction: What emotions make us think, say and do

In this document is examined the relation between emotion and attention as they interact with cognitive decisions. More specifically, the goal of this thesis was to explore the possibility that the emotionality of information can increase stimulus salience, and thereby create an illusion of familiarity when encountered within a recognition memory context.

There is ample evidence in the field of social psychology to demonstrate the effects of emotionality on a variety of social decisions. These include ratings of strangers' altruism, honesty, creativity, tolerance (Fiedler, Pampe & Sherf, 1986), attractiveness (Griffitt, 1970; White, Fishbain & Rutstein, 1981, Study 2) and facial expressions (Schiffenbauer, 1974). Studies of this nature typically involve some type of mood manipulation, such as viewing affective films or reading affective statements designed to induce either positive or negative mood, followed by a judgement task. For example, White et al. (1981, Study 2) asked one group of males to watch a comedy videotape while another group of males viewed an affectively neutral tape. Both groups then rated the appeal of an attractive and an unattractive female. The males who had watched the comedy rated the attractive female as more romantically appealing and the unattractive woman as significantly less appealing, in comparison to the ratings of those in the neutral mood group. These results indicate that positive emotional arousal may influence individuals' judgements about other people, both in a mood congruent (positive - attractive) and incongruent (positive - unattractive) direction.

Griffitt (1970) induced negative mood in a group of participants by having them work for 45 minutes in an uncomfortably hot and humid room. Another group worked in a comfortable room for the same length of time. Those who had worked in uncomfortable conditions rated their own mood as more negative and a stranger as being less attractive than did those who had worked in the comfortable environment. Similarly, individuals who had listened to a tape designed to induce feelings of disgust were more likely to rate pictures of others as conveying facial expressions of disgust and fear, in comparison to the ratings of those who had listened to an affectively neutral tape (Schiffenbauer, 1974). Together, these studies demonstrate that differences in mood can have an impact on social decisions, and that individuals may often be unaware of the bases on which such social judgements are made (but see Forgas & Moyan, 1988).

More recently, Stormark, Nordby and Hugdahl (1995) demonstrated the impact of emotionality on attentional allocation and cognition. Using emotional and neutral words as cues in an attentional shift paradigm, Stormark et al. (1995) found that emotional cues resulted in enhanced ability to focus and sustain attention to a validly cued location. This resulted in faster reaction times - a cognitive benefit. In contrast, when emotional words served as invalid cues, an increase in reaction time was noted – a cognitive cost associated with difficulty shifting attention away from emotional words. In both cases, the emotionality of the stimuli was reflected in a higher P3 amplitude, a late positive component of the event related potential (ERP). These results indicate that the emotional meaning of words may influence the ability to focus, sustain, and shift attention to other stimuli in the environment, and that the attention allocated to emotional stimuli can be defined using electrophysiological measures.

The Stormark et al. (1995) results may be generalized to suggest that in the social setting, attention may be enhanced to emotionally salient stimuli, at the cost of missing other important information (see also Bower, 1994). In effect, people may be predisposed to attend to emotionally salient information, perhaps without even being aware of it. Such an attentional predisposition may be pronounced in individuals with certain psychiatric disorders. Selective attention to threat has been proposed to contribute to the maintenance of anxiety disorders (Beck, 1976). Individuals with generalized social phobia (GSP) have been shown to exhibit enhanced attentional bias towards angry emotional faces in comparison to non-phobic controls (Gilboa-Schechtman, Foa & Amir, 1999). Using the face-in-the-crowd task in which a target face is embedded in a crowd of distracter faces, individuals with GSP were faster than controls at detecting angry faces in a neutral crowd than they were at detecting happy faces within a neutral crowd. These differences indicate enhanced attentional allocation to threat-related social cues for GSP individuals relative to normal controls. Interestingly, although phobics were faster than controls at detecting the angry faces, non-phobic controls also had faster reaction times to angry as opposed to happy faces, suggesting that people in general may be somewhat predisposed to attend to threatening emotional information (see also Stenberg, Wiking & Dahl, 1998).

Similar effects of threatening emotional cues on attention have been obtained using the Emotional Stroop task, in which a proportion of coloured words are threat-related. In this version of the Stroop task, a list of emotional and neutral words are printed in different colours of ink. The task is to ignore the meaning of the word and say aloud the colour of the ink for each word as quickly as possible. Individuals with various specific phobias have been found to be slower at colour naming threat-related words (e.g., "spider" printed in blue ink) in comparison to non-phobic individuals (e.g., Watts, McKenna, Sharrock & Trezise, 1986), as have socially anxious individuals (e.g., Hope, Rapee, Heimberg & Dombeck, 1990). These results indicate that for anxious individuals, attention may be enhanced to threat- related emotional stimuli; as a result, they experience considerably more difficulty than others shifting their attention away from anxiety-provoking faces and words.

Although most healthy individuals are generally able to inhibit emotionally based response tendencies, when necessary or appropriate, these studies show that others may experience considerable difficulty in this inhibitory process. The aim of the first experiment in this thesis was to determine if the salience generated by negatively valenced emotional words, when presented in a memory task, would be sufficient to capture the attention of normal adults and cause them to misattribute the experience to false feelings of familiarity.

Memory Attributions

The dual process theory of recognition (e.g., Kelley & Jacoby, 1998) is based on the premise that recognition involves both automatic and controlled memory processes. Recollection of details surrounding a past event is conceptualized as a controlled, analytical procedure, whereas the feeling of familiarity that accompanies past experience is thought to be a more automatic process. The dual process theory is similar to the remember/know distinction also common in the memory literature (Tulving, 1985). In this view, *remembering* is accompanied by conscious recollection of having seen an item previously, whereas *knowing* implies the experience of familiarity in the absence of a specific, episodic recollection of the event (see Knowlton. 1998 for a review).

Although controlled recollection processes are necessary for veridical remembering to occur, the subjective *experience* of remembering makes one *feel* one is remembering (Jacoby, Kelley & Dywan, 1989a) and that one has a link from the present to the past. This automatic feeling of familiarity is usually enough to make one believe one is indeed remembering, rather than simply guessing or imagining (Whittlesea, 1993). However, the link between the feeling of familiarity and remembering may sometimes become disconnected, as is the case in amnesia. Amnesics often show evidence of memory, such as improved performance on complex tasks, in the absence of conscious recollection of previous experience with the task (e.g., Corkin, 1968; Milner, 1970; Warrington & Weizkrantz, 1970). Alternatively, in the case of confabulation, the amnesic may be convinced of the validity of their answers about the past even when they are wrong (Mercer, Wapner, Gardiner & Benson, 1977). "Mismatches between subjective experience and memory representations imply that the subjective experience of remembering is an attribution or inference" (Jacoby et al., 1989a, p. 394).

Work by Jacoby and colleagues (see Jacoby et al., 1989a for a review) has demonstrated that a feeling of familiarity is not necessarily a consequence of prior experience, but may instead be mediated by an unconscious attributional process (see also Johnson, Hashtroudi & Lindsay, 1993). The basic premise underlying the attributional theory of remembering is that previously encountered information is processed more fluently, or more easily, when encountered again. Therefore, when trying to make a memory judgement, people will more likely attribute to the past, information that is processed fluently than information that is not processed as easily. People often use a heuristic such a fluency of processing when judging whether information has been seen before (Jacoby et al., 1989a; Johnson et al., 1993; Whittlesea, 1993). The idea of memory as an attributional process is similar to the idea of the perceptual process called 'unconscious inference'. In the mid to late 1800's, when scientists were beginning to study the nature of perceptual illusions, Helmholtz proposed that perception occurs as a result of unconscious inferences the mind makes about the pattern of stimulation in the nervous system (see Roediger, 1996). Thus, the mind could be made to perceive various perceptual illusions, such as the illusion of changing depth portrayed in the Necker cube. Attributions of remembering may also be susceptible to illusions, but illusions of familiarity.

According to Jacoby et al. (1989a), if remembering is indeed the result of an attribution, it should be possible to produce misattributions, or false feelings of familiarity, by arranging the experimental context so that something other than past experience is the most salient thing that "jumps out". Recently, there has been a great deal of experimental work concerning the role of processing fluency in recognition (e.g., Benjamin, Bjork & Hirshman, 1998; Jacoby et al., 1989a; Jacoby & Whitehouse, 1989; Kelley & Jacoby, 1998; Poldrack & Logan, 1998; Roediger, 1996; Wagner & Gabrieli, 1998; Whittlesea, 1993; Whittlesea, Jacoby & Girard, 1990; Whittlesea & Williams, 1998) indicating that both perceptual and conceptual fluency can have an impact on recognition judgments.

Whittlesea et al. (1990) altered the perceptual fluency of a proportion of target words in a word recognition task by varying the density of visual masks. Participants were shown a short list of words, followed by a target word. The target words were always masked. However, on half of the trials the mask was relatively dense, making words difficult to identify, whereas on the other half of trials the mask was less dense, making identification easier. Half of the target words were repeated from the list, and half were new. Participants pronounced lightly masked targets faster than heavily masked targets, and were more likely to call lightly masked words "old" even when they were new. This suggests that participants misattributed the fluency experienced by the relative ease of processing lightly masked words as being due to prior experience of the word (see also Whittlesea, 1993, experiments 1 and 4).

Similar effects on the experience of remembering occur when fluency is manipulated using semantic cues. Whittlesea (1993, experiments 3 and 5) presented previously seen and new words as the final (target) word in sentences at test. Some of the sentences were semantically predictive of the target words whereas others were non-predictive. Words presented in predictive sentences were pronounced faster than words in non-predictive sentences, indicating more fluent processing of semantically predicted words. In addition, participants claimed to "recognize" new words more often when they were presented in a predictive as opposed to non-predictive contexts. Together, these results demonstrate that by manipulating either perceptual or conceptual properties of a stimulus, individuals can be made to experience a false feeling of remembering, or an illusion of remembering (but see Wagner & Gabrieli, 1998). According to Whittlesea (1993), "the occurrence of this illusion of remembering demonstrates that the feeling of familiarity is not a direct product of memory, but instead is the product of attributing fluent processing to a source in the past" (p.1238).

It is important to note that it is *within the context of remembering* that various sources of stimulus properties, such as fluency, may be misattributed to the past (Kelley & Jacoby, 1998). If the goal of the task is something other than remembering, such as judging temporal duration (Whittlesea, 1993, experiment 6), item pleasantness (Whittelsea, 1993, experiment 5), or even fame (Jacoby, Woloshyn & Kelley, 1989b), increased fluency will not be attributed to the past but will be misattributed according to task goals. Other related factors that may mediate the interpretation of fluency include the extent to which fluent processing comes as a surprise (Whittlesea, 1993; Whittlesea & Williams, 1998), and the amount of attention paid to various stimuli (Poldrack & Logan, 1998) in the context of remembering.

Focussing on the influence of automatic processes and memory errors may cause the reader to assume that the memory attribution process is a faulty system. However, it is important to remember that controlled recollective processes are also involved in memory attributions. When sufficient detail is recollected, controlled processes may allow for the inhibition of the influence of false familiarity and lead to correct memory judgements (Jacoby et al., 1989a). Note that not all, in fact only a relatively small proportion, of fluently processed non-target words were incorrectly called "old" in the studies reviewed here. Furthermore, although errors may occur when people rely on familiarity in the absence of conscious recollection, use of a fluency heuristic in memory decisions is usually beneficial. Previous experience does indeed lead to more fluent processing (Jacoby et al., 1989a; Whittlesea, 1993) and so subjective experience is usually accurate, playing an important role in supervisory functions (Kelley & Jacoby, 1998).

As is the case of perceptual illusions, there are undoubtedly many types of memory illusions that can be caused by a variety of factors in addition to processing fluency (Roediger, 1996; see also Johnson, Nolde, Mather, Kounios, Schacter & Curran, 1997). The studies reviewed here clearly indicate that some attributional process must be involved in recognition judgements, in addition to a controlled memory search. Given these results, it seems likely that any stimuli – such as emotionally salient words - that grab our attention, or "jump out", will be accompanied by an automatic reactivity, or change in feeling state. Within the context of a memory task, the change in feeling generated in response to salient stimuli is likely to be interpreted as a feeling of familiarity. Thus, it was anticipated that within the context of a memory task, automatic neurophysiological reactivity to emotionally salient words would lead to increased fluency of processing and engender the illusion of familiarity and increases in false positive responses.

Memory for source

The use of the term 'source' when discussing memory, relates to the variety of characteristics that together specify the conditions under which a memory was acquired (Johnson et al., 1993). These source characteristics may include information about the modality of stimulus presentation as well as the spatial, temporal and social context of the original event (Johnson et al., 1993). Johnson and colleagues have developed what they refer to as the "Source Monitoring Framework" (e.g., Johnson et al., 1993; Johnson, Kounios & Nolde, 1997a). The central claim of the source monitoring framework is that people do not retrieve an abstract label that specifies the source of a memory. Rather, in a manner similar to Jacoby's memory attribution theory, activated memories are *evaluated* *and attributed* to particular sources through decision processes performed *at the time of remembering* (Johnson et al., 1993). Although controlled analytic procedures may be involved in making judgements about source, more often source monitoring decisions occur rapidly and relatively automatically, based on the qualitative characteristics of activated memories (Johnson et al., 1993). In effect, various pieces of information about a stimulus may come to mind when a person is trying to remember. The subjective interpretation of the quality of those pieces of information has a large impact on whether they will be treated as reliable memories or not.

Using ERPs to Measure Emotion, Attention and Memory

Although one can measure the increased incidence of false positive behavioural responses in a memory attribution paradigm, behavioural responses alone cannot confirm that these responses are, in fact, due to the heightened levels of neural activation that are assumed to accompany perceptually (or conceptually) fluent events. To test the theory that memory illusions are indeed based on excess excitation engendered by emotionally salient words, in the present series of studies, event-related potentials (ERPs) were gathered while participants were engaged in a running recognition task.

The EEG reflects the sum activity of a large number of neural systems. Specific neural processes tied to a particular event may be extracted from the global EEG through a simple averaging process. A particular stimulus, such as the sound of a tone, is used as a time-lock point, and EEG segments coincident with multiple trials of the tone are averaged. Any neural activity that is specific to the tone and present in every trial will remain in the average whereas any unrelated activity (noise) will become attenuated through averaging. The result of the averaging process is referred to as an event-related potential or ERP. The ERP is a continuous waveform that reflects the neural processing between stimulus onset and the end of the recording epoch. This waveform is characterized by positive and negative deflections, referred to as peaks, or components. The peaks are typically given a label consisting of a P or an N (positive or negative) and a number to indicate the temporal position of the peak in the waveform. Temporal designation may be either precise (e.g., P335, indicating a positive peak maximal at 335 ms post stimulus onset) or ordinal (e.g., P3, the third major positive peak). However, peak latencies, particularly of later components, such as the P3, often vary considerably (Luck & Girelli, 1998). For this reason, ordinal descriptions will be used in presentation (to follow) of the results of the present series of studies.

The P3, one of the most studied ERP components, is a positive wave with 300 to 900 ms latency and a characteristic scalp distribution that increases from frontal to parietal loci (Coles & Rugg, 1995). The amplitude of the P3 is thought to reflect "the neural events underlying mental processes that are fundamental to a wide range of complex cognitive activities" (Polich, 1993, p. 177). P3 latency is defined as the occurrence of the peak's maximum amplitude relative to stimulus onset (Polich, 1990). Peak latency is considered an index of stimulus evaluation time (De Pascalis, Morelli & Montirosso, 1990; Polich, 1990).

Because the latency of the P3 varies considerably (Luck & Girelli, 1998) and increases with task complexity (Polich, 1990), researchers in the ERP and memory field have begun to talk about late components in more general terms. For example, Smith (1993) describes a "memory evoked shift" in the later portions of ERP waveform approximately 350 to 850 ms following stimulus onset. Others (e.g. Dywan. Segalowitz and Webster. 1998) refer to this same late component more generally as the late positive component (LPC), or late positivity. In presenting the results of the experiments in this thesis, ERP components will be described in general terms using ordinal temporal descriptions and/or reference to their latency window (e.g.. the region from 400 – 600 ms post stimulus onset). When appropriate, the terms late positivity. late positive component. and LPC will be used interchangeably to refer to the area of the waveform with maximal positive amplitude shift within the latency window between 350 and 900 ms post stimulus onset.

ERPs and emotion

The literature on the electrophysiological correlates of reactivity to emotional stimuli is sparse and quite varied with respect to methodology. For example. in some studies, participants are asked to make a cognitive judgement about some aspect of the emotional stimulus. such as rating the level of emotionality inherent in photos or words (e.g., Vanderploeg, Brown & Marsh. 1987). In other studies, the emotional stimuli are not the focus of the task at hand (e.g. Lang, Nelson & Collins,1990; Stormark et al.. 1995). Differences of this nature prevent a clear comparison of the studies in this literature. However. despite methodological differences, emotional stimuli do seem to stand out relative to neutral stimuli in the context of a variety of experimental paradigms. In particular. differences in ERP responses related to emotional stimuli seem to be most prominent in the LPC of the ERP waveform.

Vanderploeg et al. (1987) recorded ERPs while participants made cognitive judgements about the emotionality of both visually presented pictorial (drawings of faces) and verbal (single words) emotional stimuli. The pictures and words were divided into positive, negative and neutral categories and projected as slides in three test phases. In phase one, participants viewed the stimuli and rated them for their emotional content. In phase two, pictures were paired with auditory presentations of the words. In the third phase, participants were again shown the stimuli as in phase one and were asked to rate the emotional content. ERPs were averaged based on participants' subjective emotional ratings of the stimuli. For both pictures and words, the amplitude of the P3 to the positively and negatively rated stimuli was more positive than that for the stimuli rated as neutral.

Johnston, Miller and Burleson (1986) recorded ERPs while participants rated the pleasantness of pictures that were emotionally positive (babies and adult nudes), neutral (ordinary people) and negative (dermatological procedures) in the context of a paired-associate learning paradigm. ERPs were recorded while one group of participants learned associations between consonant-vowel-consonant trigrams (CVCs) and pictures. Another group of participants viewed these CVC-pictorial pairs, but were not required to learn the associations. The paired associates learning task was included to determine if ERPs to the neutrally valenced CVCs would change as participants learned relations with high emotion pictures. No change in response to the CVCs was found. However, analysis of the ERPs to the differently valenced pictures revealed that emotion had a major influence on LPC amplitude for both groups of participants. Greater amplitude of the ERP late positivity (at 300 ms and 540 ms) was noted for both positive and negative pictures relative to neutral pictures. More recently, Kayser, Tenke, Nordby, Hammerborg, Hugdahl and Erdmann (1997) recorded ERPs while women viewed negative (dermatological diseases) and neutral (post-cosmetic surgery) photos. Greater ERP amplitude was noted in response to the negative pictures when compared to the neutral pictures, particularly in the later positive components 285 ms and 380 ms post stimulus onset.

Lang et al. (1990) used pictures of a female face modelling happiness and anger as targets (20 % of trials) in two separate conditions of a visual oddball paradigm. In the standard oddball paradigm, an infrequent target is randomly presented among a series of more frequent non-target items. Using such a paradigm. Lang et al. recorded ERPs while participants counted the number of target faces. The greatest P3 amplitude was found for negative target faces. Similarly, Erhan, Borod. Tenke and Bruder (1998) used nonsense syllables (e.g., ba, pa) spoken in emotional tones (such as happiness, anger, sadness, interest) as targets on 30 % of trials in an auditory target detection task. The target emotional syllables elicited an increase in amplitude in the later positive component of the ERP waveform.

As was the case in the Stormark et al. (1995) study, researchers do not always draw participants' attention to the emotionality of the stimuli. Even so, emotional stimuli seem to elicit greater positive shifts in ERP amplitude at approximately 300 to 400 ms post stimulus onset, relative to neutral stimuli. An unusual effect of non-attended emotionality is reported by Kostandov and Arzumanov (1986) who presented emotional and neutral words at a level below recognition threshold (stimulus duration = 15 ms). Participants were told to look at the glowing spot in front of them and count the number of times they thought a word appeared. Although participants reported seeing only a "dim light", greater P3 amplitude was observed for emotional versus neutral words.

Together, the results reviewed here suggest that emotional stimuli elicit a neural reactivity irrespective of the nature of the stimuli and irrespective of the valence of the emotion. Thus, one may conclude that emotional stimuli appear to be meaningful and salient and produce a neurophysiological response that results in a late positive ERP.

ERPs and attention

It is well accepted that later components in the ERP waveform increase in amplitude in response to stimuli that are rare and/or meaningful to the participant (c.f. Leiphart, Rosenfeld & Gabrieli, 1993). Stimulus salience may stem from either automatic or controlled processes (Jacoby et al., 1989; Johnson et al., 1993). Salience attributable to more automatic processes is typically related to the perceptual quality of the stimulus, such as fluency of processing (e.g., Whittlesea, 1993) or the automatic feeling of familiarity that accompanies previously seen words (e.g., Jacoby et al., 1989a; Johnson et al., 1993). Similarly, stimulus properties inherent in emotional words also seem to be salient and capable of capturing attention.

Stormark et al. (1995) demonstrated the impact of emotionality on attentional allocation and cognition, using emotional and neutral words as cues in an attentional shift paradigm. As discussed previously, attention to emotional words was enhanced in comparison to neutral words. This was evidenced by faster reaction times to locations validly cued by emotional words (cognitive benefit) and slower reaction times to locations invalidly cued by emotional words (cognitive cost). In both situations, the emotional words were also associated with increased late positive ERP amplitude, in comparison to neutral words. In other studies, more positive P3 amplitude was elicited by emotional as compared to neutral words, even when these words were subliminally presented (Kostandov & Arzumanov, 1986). Together, these results indicate that the emotional meaning of words may influence the ability to focus, sustain, and shift attention to other stimuli in the environment. Furthermore, the results indicate that the attention allocated to emotional stimuli can be defined using electrophysiological measures.

There are times, however, when adaptive social behaviour may require inhibition of attentional allocation to emotional stimuli. According to Engle, Conway, Tuholski and Shisler (1995), inhibition is an active process that requires attentional resources. Under conditions of optimal attentional capacity, elaborative processing of material that is not relevant for the task at hand is inhibited. However, when attentional resource capacity is reduced, the ability to inhibit responses decreases (Engle et al., 1995). Dywan et al. (1998) tested this theory by examining the impact of attentional capacity on electrophysiological and behavioural responses within the context of a source monitoring paradigm modeled after Jacoby and colleagues (see Jennings & Jacoby, 1997). Both aging and distraction are thought to result in a decline in attentional resources (Jacoby et al., 1989a), therefore Dywan et al. compared the performance of healthy young adults working under full attentional capacity to that of older adults and another group of young adults who were distracted at test.

ERPs were recorded while participants studied a list of 25 words and then engaged in a running word recognition task in which the words from the study list were interspersed with 75 new word foils. Twenty-five of the foil words (referred to as lags) repeated in the test list after a lag of 6 intervening words. In this context, the familiarity of a test word alone was not sufficient to make a correct source identification. The recently repeated lag words, although not to be considered targets in this task, would nonetheless be at least as familiar as the words previously seen on the study list. Participants were instructed to ignore the lag word repetition and press a "yes" key for only words previously seen on the study list and a "no" key for all others. Responses based solely on the fluency generated by familiar repeated words would lead to false positive responses (i.e., source errors).

It was anticipated that those working with full attentional capacity would be able to control the tendency to respond on the basis of familiarity alone, i.e., to familiar lag words. In contrast, those with decreased attentional capacity (in this case, older adults and young adults working under distraction) would not show this selectivity. Dywan et al. (1998) found that, behaviourally, young adults working under full attentional capacity were more likely to correctly reject the repeated lag items in comparison to older adults and distracted young adults. Electrophysiologically, the young adults in the full attention condition produced the most positive LPC amplitude to studied (target) words, and appeared to quickly inhibit the ERP response based on the familiarity of repeated lag words. Interestingly, both the older adults and distracted young adults produced a higher amplitude LPC to the non-target lag words, in comparison to both previously studied targets and non-repeated foils.

Similar findings were obtained in a separate study in which familiarity and targetness were again placed in opposition using a slightly different method (Dywan, Segalowitz, Webster, Harding & Hendry, under review). As described above, older and younger adults studied a list of words and were then shown a test list in which a proportion of the new words repeated. Half of the participants (half of each age group) were tested under the standard lag procedure described above, so that they were asked to ignore the repeating new words and hit "yes" only for previously studied words. In contrast, the other half of the participants were told to hit "yes" only for the repeated new words, and to hit "no" for all other words including the previously studied words (lag target condition). In the standard condition, older and younger adults did not differ in terms of their behavioural responses to target words but older adults were more likely to make false positive responses to the repeated foils. Also, as seen previously (Dywan et al., 1998) older adults produced an elevated ERP response to the repeated lag words in comparison to the target studied words, whereas young adults produced the expected late positivity to target items but not to the lag words. In the lag target condition, both older and younger adults produced a more positive amplitude response to the target lag items than to the studied words. In this case, both targetness and recency combined to make the repeated lag words highly salient.

Together, the results of these two experiments indicate that for young adults, goal relevance of a given stimulus has a great impact on ERP response. Young adults produced the greatest positive amplitude shift for target words, whether they were previously studied words or lag words. Older adults on the other hand, were not characterized by such flexibility in their neural response. Older adults produced an enhanced amplitude shift to most recently repeated lag words regardless of whether they had been designated targets or not. Given these findings, Dywan et al. (1998) conclude that "for young adults [working under full attention conditions], the amplitude of the late positivity corresponds with the salience of goal relevant information. That is, the late positivity would reflect the targetness of the stimulus rather than its familiarity *per se*" (p.

417). In contrast, reduction of attentional capacity (either by aging or distraction) allows stimulus properties not relevant to the task goals to influence memory response tendencies.

In summary, evidence from the cognition literature indicates that the emotionality of stimuli may influence attentional processes. Stormark et al. (1995) demonstrated that attention to emotional information may be enhanced relative to non-emotional information, even in healthy young adults working under full attentional capacity. Dywan et al. (1998; under review) demonstrated that attentional capacity is associated with inhibitory control processes. In addition, both groups showed that attentional differences could be captured using electrophysiological techniques. However, to date, no one has examined the role of attentional capacity in the inhibition of electrophysiological and behavioral responses to emotionally salient information. The studies comprising this thesis were designed to do just that.

ERPs and memory

ERPs elicited by repeated items are generally more positive than those elicited by items encountered for the first time (Bentin & McCarthy, 1994; Fabiani, Karis & Donchin, 1986; Paller & Kutas, 1992; Rugg, 1995). This positivity increases with repeated presentation (Segalowitz, VanRoon & Dywan, 1997) and is observed in both younger and older adults to about the same degree (e.g., Friedman, Hamberger & Ritter, 1993; Rugg, Pearl, Walker, Roberts & Holdstock, 1994).

The left parietal effect

Studies of recognition memory have consistently revealed a distinct neurophysiological correlate of previous experience. In comparison to new words, correctly identified studied words elicit a positive-going waveform that begins about 300 to 400 ms following stimulus onset and lasts for 400 to 600 ms (Dywan et al., 1998: Smith, 1993; Segalowitz et al., 1997; Tendolkar & Rugg, 1998; Wilding & Rugg, 1997). This waveform has a characteristic topographical distribution across the scalp, with maximal positivity at left parietal electrodes (Allan & Rugg, 1998; Donaldson & Rugg, 1998; Johnson, Kreiter, Russo & Zhu, 1998; Mark & Rugg, 1998; Rugg, Schloerscheidt & Mark, 1998; Schloerscheidt & Rugg, 1997; Tendolkar & Rugg, 1998). This effect has been referred to as the memory-evoked shift (Smith, 1993), the late positive component (Dywan et al., 1998; Rugg, Mark, Gilchrist & Roberts, 1997), the parietal old/new effect (Schloerscheidt & Rugg, 1997; Wilding & Rugg, 1997), or, most specifically, the left parietal old/new effect (Tendolkar & Rugg, 1998). Regardless of the label used to describe it, this pattern of ERP activity is thought to reflect neural processes involved in the discrimination of old from new items, and is generally considered to be an index of recollection (Allan & Rugg, 1998; Mark & Rugg, 1998; Smith, 1993; Tendolkar & Rugg, 1998; Wilding & Rugg, 1997).

The right frontal effect

Currently, there is general consensus today that memories (including memories for source information) are stored throughout the neocortex, whereas the frontal lobes may be particularly important for retrieval and evaluation of that information held elsewhere (Johnson et al., 1997a). Results of recent neuroimaging studies (e.g., Smith, Marshuetz, Jonides & Koeppe, 1998) have shown that the frontal lobes are involved when individuals are asked to discriminate recently presented verbal stimuli from similar verbal stimuli not recently presented. Wilding and Rugg (1996) found a right lateralized frontal ERP positivity when participants were asked to judge whether recognized words were originally heard spoken by a male or female voice. Johnson et al. (1997a) also observed a right frontal positivity when participants were required to identify the source (drawings or words) of previously encountered information, as opposed to simply making old/new discriminations. There is some evidence that the right frontal positivity may begin in a bilaterally distributed fashion approximately 300-400 ms following word onset, shifting to a right frontal maxima over approximately 1000 ms (Wilding & Rugg, 1997). Similar right frontal effects have also been observed in the context of recognition memory tasks even when no explicit source decision was required (e.g., Donaldson & Rugg, 1998; Rugg, Schloerscheidt & Mark, 1998; Schloerscheidt & Rugg, 1997; Wilding & Rugg, 1996). These findings have lead to the suggestion that right prefrontal regions may contribute to the retrieval of episodic information (Schloerscheidt & Rugg, 1997), and are involved in the evaluation and integration of context and item information (Rugg, Fletcher, Frith, Frackowiak & Dolan, 1996; Wilding & Rugg, 1996).

In the present series of experiments, participants were asked to discriminate between automatic (emotional) and controlled (targetness) sources of stimulus salience at test and make a decision as to whether test items had been previously studied or not. In this context, one would expect to observe the left parietal old/new effect, as well as a right frontal positivity, possibly related to the neural processes involved in evaluating and distinguishing between sources of item salience.

Interpreting the LPC in the context of remembering

Functional interpretations of the ERP old/new effect have generally been made within the framework of dual process theories of recognition memory (Wilding & Rugg, 1997). One of the most influential dual process theories is that of Jacoby and colleagues (e.g., Jacoby & Dallas, 1981; Jacoby et al., 1989a; Kelley & Jacoby, 1998). As described in detail in a previous section of this document, Jacoby's dual process theory is based on the position that recognition involves both recollection of previously encountered information as well as a feeling of familiarity for that information. There has been some debate as to whether the ERP effect represents an index of relatively automatic "familiarity" (e.g., Friedman, 1990; Rugg & Doyle, 1992), or of conscious "recollection" (e.g., Smith & Halgren, 1989; Van Petten, Kutas, Kluender, Mitchiner & McIsaac, 1991; Wilding & Rugg, 1996). Others (e.g., Karis, Fabiani & Donchin, 1984; Neville, Kutas, Chesney & Schmidt, 1986) have proposed that, rather than reflecting either component of recollection, the ERP effect may reflect indirect processes involved in item discrimination, such as the experience of higher confidence and/or lower subjective probability for old words compared to new words. Regardless of the debate over the details, most agree that the ERP old/new effect represents some aspect of recollective processes.

However, the mnemonic specificity of the ERP old/new effect has been called into question by results of recent work by Dywan and colleagues (e.g., Dywan, et al., 1998; Dywan et al., under review). As described in detail in the previous section on ERPs and attention, Dywan et al. found that even though one can produce a late positive amplitude shift on the basis of word repetition, the most dramatic shifts in amplitude occur for targeted as opposed to non-targeted stimuli – irrespective of their relative familiarity. When a studied item is the target in a word recognition test, young adults produce the expected increased LPC amplitude for those words and little amplitude shift for more recently presented lag words. However, when told to ignore previously studied words at test and treat lag words as targets, young adults produced the greatest LPC amplitude shift for lag words. These results indicate that for young adults, goal relevance of a given stimulus has a great impact on ERP response (see also Wilding & Rugg, 1997).

These findings suggest that the ERP late positivity effect may not be a direct index of familiarity, recognition, or recollection. Rather, the LPC may "represent the degree to which the stimulus appears to be salient to the individual" (Dywan et al., 1998, p. 426). If this hypothesis were valid, one would expect salient stimuli, such as emotional words or pictures, to elicit enhanced ERP late positivity even in the absence of previous exposure. At the outset of this thesis, I hypothesized that the automatic reactivity engendered by emotionality could be misattributed to a feeling of familiarity, when encountered within the context of a memory task. This feeling would then lead to an increase in the proportion of memory errors or false memories for new emotional foil words. In other words, mnemonic errors would occur when the source of neural arousal generated by emotional words is not attributed to the automatic reactivity to emotional salience, but is instead misattributed to a source in line with the controlled cognitive goals of the task, that is, to past experience.

Emotion in the Context of Remembering

There is a fairly large body of literature concerning the impact of mood or emotional state on memory (for reviews, see Baddeley, 1990; Bower, 1994; Lazarus, 1994). Evidence of mood-congruity effects indicates that people are more likely to remember information that is congruent with their emotional state, or mood. Happy people remember happy events better, and sad people remember negatively valenced events in more detail than neutral events. However, there is also "abundant evidence...that people better remember events that evoke greater emotional reactions, whether positive or negative" (Bower, 1994, p. 305). For example, when participants were instructed to focus on their emotional reactions to provocative statements, recall of the content of statements was at least as good if not better than recall of the statements when participants focussed on how they thought the speakers felt (Johnson, Nolde & De Leonardis, 1996). Word emotionality (in both positive and negatively valenced directions) has been shown to have a significant impact on whether or not words will be spontaneously recalled (Rubin & Friendly, 1986). According to Bower (1994), the impact that emotionality has on memory is mediated by attentional processes. In effect, emotionally salient stimuli are attention-grabbing, and so receive more initial processing than neutral stimuli, and so are consequently remembered better.

Despite the impact that emotion has been shown to have on attentional and memory processes, prior to the present study, no one had attempted to directly manipulate word emotionality in order to induce false feelings of familiarity within a source monitoring paradigm. Although one previous study included emotional and neutral words in a recognition memory paradigm (Leiphart, Rosenfeld & Gabrieli, 1993), unusual methods employed in that study prevent clear interpretation and generalization of the results. Thus, the present study was expected to reveal novel information concerning the impact of stimulus emotionality on memory attributions. It was also expected that previously studied emotional words were expected to be recognized more frequently than previously studied neutral words. As well, although mood was not manipulated, participants in a depressed mood at the time of test were expected to "recognize" a relatively greater proportion of emotional words (regardless of whether the emotional words were actually studied or were new foils) in comparison to non-depressed participants because depressed individuals were expected to be more attuned to emotional stimuli in the environment. Finally, the results of the present study were expected to add novel information to the emotion and memory literature with regards to whether or not attentional allocation and reactivity to the emotionality of non-target words could lead to illusions of remembering.

Topographical Distribution of ERPs to Emotional Stimuli

The cognitive processes associated with emotionality may not be fully equated with those related to word recency or repetition. Topographical analyses were planned to investigate potential effects of both emotionality and previous experience on ERP distributions. Results of previous research with non-emotional words indicate that the LPC to recognized words is larger over the left hemisphere, particularly in the parietal regions (e.g., Joyce, Paller, McIsaac & Kutas, 1998; Tendolkar & Rugg, 1998). However, in the Joyce et al. (1998) study, notable lateralization was observed only for words that had been semantically encoded and was greatly reduced for non-semantically encoded words. Asymmetry was virtually absent for new words and was absent altogether for a group of older adults (Joyce et al., 1998).

There is some evidence that the processing of emotional words may have a different topographic organization than that seen following neutral words. Based on consistent behavioural findings, there is general consensus in the literature that the right hemisphere processes most emotional stimuli more efficiently than does the left hemisphere (e.g., Bryden & Bulman-Fleming, 1994; Bryden, Free, Gagne & Groff, 1991; Bulman-Fleming & Bryden, 1994 & 1995; Herrero & Hillix, 1990; Hirschman & Safer, 1990; Mondor & Bryden, 1992; McNeely & Netley, 1998; Morais & Ladavas, 1987; Shipley-Brown, Dingwall, Berlin, Yeni-Komshian & Gordon-Salant, 1988). Similar results have also been shown using ERPs. For example, greater P3 amplitude has been observed at the right centroparietal area for positive and negative faces, in contrast to symmetrical activation for neutral faces (Laurian, Bader, Lanares & Oros, 1991). Similarly, Vanderploeg et al. (1987) found that positive and negative faces elicited higher LPC amplitudes in the right hemisphere compared to the left, with right anterior sites being most positive. However, others have failed to find hemispheric differences for ERPs to emotional facial expressions (e.g., Carretie & Iglesias, 1995).

With regards to the lateralized processing of words with emotional meaning, it has generally been assumed that these words are processed by left hemisphere language centres as are other words (Heilman, Bowers & Valenstein, 1993). However, some clinical neuropsychological research with unilaterally brain injured patients has indicated that the right hemisphere might also be involved in the processing of emotionally meaningful words (Borod, Andelman, Obler, Tweedy & Welkowitz, 1992; Reuterskiold, 1991). Some support for the role of the right hemisphere in processing emotional words has also been found in electrophysiological studies with cerebrally intact participants. For example, Vanderploeg et al. (1987) observed greater right hemisphere ERP late positivity to visually presented emotional versus neutral words in both anterior and posterior regions.

In the context of the source-monitoring task being employed in the present series of investigations, it is possible that lateralized effects due to emotionality may be masked by activation of brain regions required for source identification. Johnson et al. (1997) demonstrated that source identification is dependent on frontal lobe functions, and frontal processes also seem to be involved in inhibitory control processes (Dywan et al., 1993; Smith et al., 1998). Given the influence of task requirements on regionalized differences, it is hypothesized that frontal activation resulting from processing involved in source identification and inhibition of responsivity to non-target words may mask asymmetric frontal differences that result from processing of emotional words. Nevertheless, topographical analysis of the distribution of ERP waveforms across the scalp could reveal interhemispheric differences in the reactivity to emotional as opposed to neutral words.

EXPERIMENT 1

Dywan et al. (1998) have proposed that the LPC occurs as a function of more salient relative to less salient events within a particular task context. Thus, the neural response may serve as a general cue that an item is important, but the interpretation of why it is important may depend on the context in which the response occurs. It was anticipated, therefore, that in the context of a recognition task, the neural response elicited by the emotionality of a stimulus would be misinterpreted as evidence of familiarity. That is, emotional words would elicit a higher amplitude late positivity than neutral words, which would increase the likelihood of these emotional words being "recognized" regardless of whether they had actually been seen before. It was this hypothesis that experiment 1 was designed to test. In effect, this paradigm would allow for study of the misattribution process itself, to determine if it is stimulus salience of any nature, or familiarity in particular, that can lead to source errors and increased amplitude of the LPC.

The results of experiment 1 were expected to clarify, confirm and extend current knowledge concerning behavioural and electrophysiological responses to emotional, as compared to neutral, words. Although there is evidence in the literature to suggest that ERPs to emotional words differ from those to neutral words, these studies are few in number and methodological differences prevent any consistent conclusions in this regard. It was predicted that previously studied emotional words would be recognized more frequently than previously studied neutral words, and that this difference would be more pronounced in the event that participants were in a depressed mood at test. In addition, topographical analysis of ERP responses was expected to reveal possible interhemispheric differences in the processing of emotional versus neutral words. These predicted effects were not expected to be large. as young adults working under full attentional capacity would be the group most able to inhibit reactivity to salient yet non-target stimuli within the context of a recognition task. Any influence of emotion in such a sample would provide strong evidence for an attentional bias to emotionally salient stimuli.

Method

Participants

A total of 31 Brock University undergraduates participated for partial fulfillment of research requirements for a course in Introductory Psychology. After eliminating those who did not meet screening criteria, outliers, and those cases for which technical difficulties were experienced during data collection, a total of 13 cases[1] remained (mean age = 20, S.D. = 1.15 years).

Materials

Source Monitoring Task. Stimuli for the study and test lists included emotional and neutral words between 4 and 7 letters in length, and matched for frequency in the English language (Kucera & Francis, 1967). The study list was composed of 20 emotional and 20 neutral words, randomly distributed throughout the list. In order to ensure an appropriate ratio of target to non-target items, the test list was composed of the 40 study words randomly interspersed with 226 new words (40 emotional and 186 neutral), for a total of 266 words. Six neutral filler words were inserted at the beginning of the test list and were not scored; they were included simply to allow participants time to orient themselves to the requirements of the source monitoring task, and control for possible recency effects for words from the study list. The three types of words were distributed in the test list in a semi-randomized fashion in order to prevent successive presentation of multiple study and/or emotional foil words. As both study and new emotional words were expected to elicit enhanced ERP amplitude, successive

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[1] Six cases were lost due to equipment malfunction and/or experimenter error: 5 cases were eliminated as outliers, these pcs. appeared "under-responsive" as they failed to exhibit the well established ERP positivity to neutral study words: 2 cases were eliminated as outliers on the basis of excessive error rates; 2 were eliminated due to excessive eye movement artifact; and 3 were eliminated as they did not meet health screening criteria.

presentation of words from either of these categories could confound interpretation of the ERPs. To control for the possibility that responses would be attributed to a particular set of stimuli, three different versions of study and test lists were created. Words used as study items on version 1 became foils on version 2 and so on. Version order was counter-balanced across participants.

Words were presented one at a time on a computer monitor (black letters on white background) for 1400 ms each in the study condition and 250 ms in the test condition, with an inter-trial interval of 3000 ms at both study and test. The stimuli subtended a vertical visual angle of 0.4 - 0.5 degrees and a horizontal visual angle of 2.1 - 4.2 degrees, depending on the length of the word and slight differences in the distance between the participants' eyes and the monitor.

Study Word Recognition Test. In order to control for possible influences of poor memory on source monitoring, a recognition test was administered. A list composed of the 40 study words randomly interspersed with 40 never-used emotional and neutral foils was presented immediately following the source monitoring task. Participants were asked to circle all the words that they recognized from the study list.

Vocabulary (WAIS-R). In this test, participants were asked to state the meaning of 30 words. It was included to ensure that all participants meet criteria for proficiency in the English language, and to control for potential differences in verbal intelligence and the impact such differences might have on memory for words.

Digit Symbol (WAIS-R). In this task, the numbers one to nine are paired with different nonsense symbols printed in a key at the top of the test form. Below this there are four rows of blank spaces each with a number printed above. Participants were required to fill in the blank spaces, as quickly as possible, with the symbol that corresponded to the number printed above the blank space. This test was used to obtain a general index of attention, which was then correlated with source monitoring performance measures to determine the impact of attention on memory and frequency of source errors.

Health-History Questionnaire. Participants completed a health screening and general background questionnaire to ensure that they were free of any non-normative medical conditions (such as seizure disorder) and/or learning disabilities (such as dyslexia) that may have an impact on their performance and/or ERP data.

Beck Depression Inventory (BDI; Beck, 1967). This standardized self-report test contains 21 items and has proven to be a reliable and valid measure of intensity of clinical depression in many populations, including university student samples (Beck, Steer & Garbin, 1988). Participants selected statements that best described how they had been feeling over the preceding week, including the test day. A total BDI score (maximum = 63) was calculated based on a distribution of scores for each item that ranged from zero for no depressive symptomatology to three for severe depressive symptomatology. This test was included to control for the possible influence of depressed mood on participants' responses to emotional stimuli in the context of the source monitoring task.

Electrophysiological Recordings

During the study and test phases of the source monitoring task, ERPs were recorded from 17 cap-mounted tin electrodes (Fz, Cz, Pz, F3, F4, F7, F8, C3, C4, T3, T4, T5, T6, P3, P4, O1, O2) using the International 10-20 system of electrode placement (Jasper, 1958), with right ear reference and mastoid ground. The left ear was recorded as a channel and data were re-referenced offline to an average of the two ears. Horizontal and vertical eye movements were recorded from electrodes attached to the supraocular and outer canthus of the right eye, and were used for ocular artifact rejection. The EEG and EOG were amplified by a gain of 40 000 with a 12 bit sensitivity window of ± 250 μV. Impedences were established at below 5 kOhms.

Procedure

Testing procedure was explained and each participant gave written informed consent. The vocabulary and digit symbol screening tasks were completed first, followed by the source monitoring task. Electrophysiological responses were monitored while participants performed the study and test phases of the source monitoring task[2]. The study list was shown twice in order to ensure adequate encoding. During both presentations of the study list, participants were asked to sit quietly and look at each word carefully so that they would recognize it if they were to see it again later. The test list was presented following a brief, distraction-filled, delay of approximately 4 minutes, during which time the examiner explained the instructions for the subsequent aspect of the task. Participants were instructed that they would be shown a new, longer list. They were asked to look at each word carefully, and, using their dominant hand, press one key on the computer keyboard if they recognized the word from the study list and another key if they did not recognize the word from the study list (*e* or *f* key for left handers and *i* or *j* key for right handers). Response keys were counter-balanced across participants. Once it was clear that participants understood the instructions, stimulus presentation and recording of electrophysiological responses was initiated by the examiner.

Following completion of the source monitoring task, participants completed the paper and pencil recognition test for words from the study list. Electrophysiological monitoring equipment was removed, and the Health-History Questionnaire and BDI were completed. Participants were asked for their impressions of the purpose of the experiment, and their responses were recorded by the examiner. Finally, participants were debriefed and thanked for their help.

[2] Although ERP data were collected during initial stimulus presentation, insufficient artifact free trials prevented analyses of these data.

Results

Behavioural Data

Table 1 indicates the proportions of items designated "study" for each word category (emotional and neutral study words, emotional and neutral foil words). Source error is represented by the proportion of foil words incorrectly designated "study" at test. Because foil words were never repeated from the study list, or within the test list, the feeling of familiarity for these words is an illusion.

TABLE 1

Proportion of Words Judged to be from the Study List in Experiment 1

Word Type	Mean Proportion (SD)		Reaction Time (SD) (milliseconds)	
Emotional Study	.64	(.18)	881	(71)
Neutral Study	.52	(.23)	905	(119)
Emotional Foil	.13	(.13)	763	(125)
Neutral Foil	.04	(.04)	712	(109)

The proportion of test words designated "study" was entered as the dependent variable in a 2x2 repeated-measures analysis of variance (ANOVA) with previous occurrence (study vs. foil) and emotion (emotional vs. neutral) as within-subjects variables (see ANOVA Table, Appendix A-1). As anticipated, there was a main effect of previous occurrence, $F\ (1, 12) = 115.54$, $p < .001$, $\eta^2 = .91$, indicating that words previously studied (M = .58, SD = .18) were more likely to be identified as target words than were foil words (M = .09, SD = .09), regardless of emotionality. However, emotion also had a significant influence on source judgements. There was a main effect of emotionality, $\underline{F}$ (1, 12) = 8.75, p =.012, η^2 = .42, indicating that, regardless of previous occurrence (study or foil), emotional words (M = .39, SD = .14) were more likely to be identified as study words than were neutral words (M = .28, SD = .12). The interaction between emotionality and previous occurrence was not significant.

Response times were recorded at test. For each category of test word, mean reaction times were calculated based on correct responses only, and were entered into a 2x2 repeated-measures ANOVA with previous occurrence and emotionality as the within-subject factors. There was a main effect of previous occurrence on reaction time, $\underline{F}$ (1,12) = 22.24, p = .001, η^2 = .65. Increased response time was found for previously studied words (M = 893 ms, SD = 85 ms) in comparison to new words (M = 738 ms, SD = 101 ms). There was no effect of emotionality on response time, nor was there an interaction.

Correlation among behavioural measures

Simple Pearson product moment correlation coefficients (*r*) were calculated to assess the relations among variables (see Table 2). In particular, it was hypothesized that differences in vocabulary, general attention, and depressed mood might account for some of the variance in source monitoring performance. The relations of interest are discussed below.

Before calculating the correlation coefficients, the general tendency to make false positive responses on both the running recognition task and the paper recognition task was controlled. The proportion of false positives to neutral foils was regressed out of the following proportions of words designated "study" during the source monitoring test: study words (regardless of emotion), emotional study words, neutral study words, and emotional foils. The tendency to make false positive responses on the paper recognition test was partialled out of the proportion of study words selected on that test using a regression method. Thus, correlations were calculated between the other behavioural measures and the residuals of the recognition measures after controlling for general response bias.

TABLE 2

Simple Correlation of Behavioural Measures in Experiment 1

	SH	ESH	NSH	ESE	NSE	Rec
Recognition	.55*	.43	.54	.12	.15	----
Vocabulary	.33	.42	.23	.40	-.22	.17
Digit-Sym.	-.07	-.02	-.09	.39	.22	-.14
BDI	-.71**	-.51	-.71**	-.06	-.16	-.67**

Note: SH = study word hits; ESH = emotional study word hits; NSH = neutral study word hits; ESE = emotional foil source errors; NSE = neutral foil source error; Rec. = post-test recognition of study words relative to new foils.

** Correlation significant at p<.001; * correlation significant at p<.05.

Study word recognition test

Memory for the study words was verified with a paper and pencil recognition test following completion of the running recognition task. Participants recognized a mean proportion of .73 (SD = .17) of the study words, indicating good memory for the study list. As expected, the proportion of studied words recognized on this test was positively correlated ($r = .55$, $p < .05$) with the proportion of studied words accurately recognized in the running recognition test. even after the general tendency to hit "yes" at test (i.e.. the proportion of source errors to neutral foils) was controlled.

Vocabulary (WAIS-R)

Raw vocabulary scores were obtained (M = 45.69, SD = 7.23). and scaled scores were calculated based on the age of each participant. A mean scaled score of 10.54 (S.D. = 1.85) was obtained, indicating that all participants performed within normal limits on this measure. Raw vocabulary scores were not significantly correlated with the proportion of studied words accurately recognized either during the running recognition task, or on the final paper recognition task. Nor was vocabulary ability related to the tendency to make source errors to emotional or neutral foils. This indicates that performance on the source monitoring test was not due to differences in vocabulary ability in this sample.

Digit symbol (WAIS-R)

Raw scores on this measure were obtained (M = 69.23. SD = 12.58) and mean age corrected scaled scores were calculated (M = 12.23. S.D. = 2.89). All participants performed within normal limits on this scale. Raw digit-symbol scores were not significantly correlated with any of the other behavioural measures in this sample.

Beck Depression Inventory

Overall, this sample of undergraduates obtained a mean BDI score of 6.54 (S.D. = 5.21), indicating in general, a very mild level of depressive symptoms (Beck et al., 1988). Scores ranged from 2 indicating almost no depressive symptomatology to 18 indicating moderate depressive symptomatology. Very interesting relations emerged between BDI scores and source monitoring performance measures. There were significant negative correlations between BDI score and the proportion of accurately recognized study words, both on the running recognition task ($r = -.71$, $p < .01$) and on the paper recognition task ($r = -.67$, $p < .05$), indicating that the more depressed an individual was at time of test, the poorer his or her ability to recognize the studied words. Interestingly, the negative correlation with study word accuracy held only for neutral study words ($r = -.71$, $p < .01$) but was less reliable for emotional study words ($r = -.51$, $p = .08$). These findings suggest that although depression is related to a general decline in memory performance, this decline may be somewhat less steep for negatively valenced information.

ERP Responses

General observations

Grand average ERP waveforms based on correct trials only (i.e., hits or correct rejections) for emotional and neutral study words and emotional and neutral foil words are shown for all 17 electrode sites in Figure 1. Visual inspection of the waveforms reveals two distinguishable ERP components. The first occurs during the latency window of 400-800 ms and the second from 800-1400 ms post stimulus onset. The first component observed here corresponds most closely to the late positive component (LPC) usually associated with repetition and commonly observed in the context of memory tasks. This first component will be referred to as the LPC.

During the first latency window, the impact of both previous occurrence and emotional salience is clearly visible in the waveforms over all sites. The most prominent waveform across sites is that elicited by words that are both emotionally salient and previously seen (emotional study words). These two sources of responsivity can be distinguished at frontal and central sites where a slightly more positive waveform is noted for neutral studied words relative to emotional foils. However, at temporal and posterior sites, the influences of previous occurrence and emotional salience on the ERP response appear virtually identical. This phenomenon is most pronounced at sites O1 and O2 where emotional foils elicit a more positive LPC than do neutral studied words. At these most posterior sites, the greatest amplitude shift is maintained for emotional words that had been studied; however, the waveforms representing the two sources of salience, emotion alone (emotional foils) and previous occurrence alone (neutral study words), are identical. In contrast, the waveform generated in response to non-studied non-emotional foil words shows only a small positivity.

Thus, inspection of the ERP waveforms indicates that the late positive amplitude shift typically elicited by previously encountered stimuli may also be elicited by emotional items that have not been seen before in the experimental context. The similarity of the waveforms generated in response to both emotional foils and neutral study items suggests that the LPC may not reflect previous occurrence *per se*, but rather, may rather reflect a response to the relative salience of the stimulus to the participant within the experimental context.

The second component observed here, maximal from 800 to 1400 ms post onset, will be referred to as the second late component or LC2. During this later portion of the waveform, a distinction between emotional salience and previous occurrence can be observed. The positivity to emotional salience noted earlier in the waveform is maintained such that the waveform for emotional foils is clearly the most positive across sites. In contrast, the positive response to studied items that had been observed between

400 and 800 ms after stimulus onset declines dramatically into a late negativity from 800-1400 ms.

Statistical analyses

Areas under the curve formed mean LPC and LC2 amplitudes, based on correct trials only, for each word condition: emotional and neutral study words and emotional and neutral foil words. These mean amplitudes were entered into separate repeated-measures analyses of variance (ANOVA) for each latency window.

Late Positive Component (LPC, 400-800ms post onset)

Mean LPC amplitude was obtained for each word category at all 17 sites (see Appendix B-1). Previous occurrence and emotionality served as within-subject factors in repeated-measures ANOVAs. Separate ANOVAs were performed on data from midline (see Figure 2) and lateral (see Figure 3) sites. The main areas of interest in recognition judgements concern frontal and parietal lateral sites. Therefore, the results of midline analyses will be presented only when those analyses add to our interpretation of the effects seen at lateral sites. When an ANOVA gave rise to a significant interaction, the ANOVA was repeated with data normalized using a scaling procedure based on McCarthy and Wood (1985) and as described by Ruchkin, Johnson and Friedman (1999). These latter analyses were conducted to determine whether effects that differed in scalp distribution were significant after removal of possible artifact resulting from general differences in amplitude across conditions. In these and all other analyses, F ratios are reported with degrees of freedom adjusted by the Huynh-Feldt procedure to correct for nonsphericity when necessary.

A 2x2x2x2 repeated-measures ANOVA was conducted on LPC amplitude at lateral sites (F3, F4, P3, P4), with previous occurrence (studied word vs. foil), emotionality (emotional vs. neutral), lateral plane (left vs. right hemisphere) and sagittal plane (frontal vs. posterior region) as within-subject variables (see ANOVA Table, Appendix A-2). There was a significant main effect of emotionality, $\underline{F}$ (1,12) = 6.69, p = .024, η^2 = .36. The mean LPC amplitude to emotional words (M = 4.48 μV) was more positive than that observed for neutral words (M = 2.33 μV) regardless of whether they had been studied or not. The impact of emotion is underscored by the fact that at posterior sites (P3 and P4), the amplitude to emotional foils exceeded that of neutral studied words (see Table 3), as is clearly visible in the ERP waveforms at lateral sites (Figure 3). There were no other main effects nor interactions. Although previously studied words (M = 4.48 μV) elicited a more positive amplitude shift compared to foils (M = 2.33 μV) across all lateral sites, the difference did not reach significance. There was also a trend towards a greater positive amplitude shift in the right (M = 3.82 μV) than the left (M = 2.99 μV) hemisphere.

TABLE 3

Mean LPC Amplitude (μV) for

Neutral Study Words and Emotional Foils at Lateral Sites in Experiment 1

	F3		**F4**		**P3**		**P4**	
Word Category	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**	**Mean**	**S.D.**
Neutral Study	3.25	6.77	3.74	6.76	2.58	6.31	3.56	6.07
Emotional Foil	2.38	4.28	3.08	5.32	3.64	4.08	4.08	4.82

Note: F3 = left frontal; F4 = right frontal; P3 = left parietal; P4 = right parietal.

Separate analyses restricted to frontal and parietal electrodes were done to test for the right frontal effect that would be indicative of neural processes associated with source monitoring, and to test for the left parietal old-new effect expected in the context of a recognition task. At frontal electrodes, there was a main effect of previous occurrence, $\underline{F}$ (1,12) = 6.86, p = .022, η^2 = .36, regardless of emotionality, as well as a main effect of site, $\underline{F}$ (1,12) = 5.53, p = .037, η^2 = .32. In frontal regions, previously studied words were associated with a significantly more positive neural activity (M = 5.11 µV) than were new words (M = 1.96 µV). In addition, overall neural activity was more positive in the right (M = 4.25 µV) than the left frontal (M = 2.83 µV) region, thus replicating previous findings in the source monitoring literature (see ANOVA Table Appendix A-3).

In contrast, a separate comparison restricted to parietal electrodes revealed a main effect of emotionality, $\underline{F}$ (1,12) = 6.57, p = .025, η^2 = .35. At parietal sites, emotional words (M = 4.76 µV) were associated with more positive mean LPC amplitude than were neutral words (M = 2.31 µV) regardless of whether they had been studied previously or were new. Interestingly, the left parietal old/new effect was not observed. Rather, there was a trend towards greater activity in the right parietal region, $\underline{F}$ (1,12) = 4.59, p = .053, η^2= .28, possibly reflecting the lateralization of neural activity involved in the response to emotionality (see ANOVA Table Appendix A-4).

<u>Second Late Component (LC2)</u>

Mean LC2 amplitude was obtained for each of the four word conditions across all 17 sites (Appendix B-2). At lateral sites, previous occurrence (studied word vs. foil), emotionality (emotional vs. neutral), lateral plane (left vs. right hemisphere) and sagittal plane (frontal vs. posterior region) were entered as within-subjects variables in a 2x2x2x2 repeated-measures ANOVA on LC2 amplitude (see ANOVA Table, Appendix A-5). There was a main effect of previous occurrence, $\underline{F}$ (1,12) = 8.16, p = .014, $\eta^2 = .41$, as the neural response to previously studied words declined into a late negativity, (M = -0.92 μV) in contrast to the positivity noted for foils during this latency window (M = 1.77 μV). There was a main effect of lateral plane, $\underline{F}$ (1,12) = 4.93, p = .046, $\eta^2 = .29$. Significantly more positive-going neural activity was seen in the right (M = 0.81 μV) versus the left (M = 0.04 μV) hemisphere. There was a trend towards a main effect of emotion, as emotional words were associated with a more positive amplitude (M = 1.35 μV) relative to neutral words (M = -0.51 μV) during this latency window. There was also lateral by sagittal plane interaction, $\underline{F}$(1,12) = 9.55, p = .009, $\eta^2 = .44$. Positivity was generally maintained across the right hemisphere (frontal M = 1.01 μV; parietal M = 0.60 μV) and in the frontal region of the left hemisphere (M = 0.86 μV). However, a markedly negative shift in amplitude occurred in the posterior region of the left hemisphere (M = -0.78 μV). Paired t-tests revealed a significant difference between the left and right posterior regions, $\underline{t}$(12) = -3.54, p = .004 (two tailed).

A 2x2x3 repeated-measures ANOVA was performed on mean LC2 amplitude at midline sites, with previous occurrence (study vs. foil), emotionality (emotional vs. neutral) and site (Fz, Cz, Pz), entered as within-subject factors (see ANOVA Table Appendix A-6). There was a main effect of previous occurrence, $\underline{F}$ (1,12) = 15.69, p = .002, $\eta^2 = .57$. During this latency window, there was a greater negativity for previously studied words (M = -1.53 μV), which differed from the positive amplitude maintained for foil words (M = 1.90 μV). There was also a significant main effect of emotion, $F(1,12) = 5.07$, $p = .044$, $\eta^2 = .30$ at the midline sites, which was only a trend at the lateral sites ($p = .07$). Regardless of whether they had been studied or were new, emotional words (M = 1.28 μV) maintained a more positive amplitude than neutral words (M = -0.91 μV). There was a main effect of site, $F(1.39,16.66) = 5.48$, $p = .02$, $\eta^2 = .31$, with most positive amplitude maintained at Fz (M = 1.13 μV) compared to Cz (M = 0.17 μV) and Pz (M = -0.74 μV). The interaction between previous occurrence and site was no longer significant when tested with data scaled for overall amplitude differences.

Temporal Sequence of Topographical Distributions

To provide additional information on the temporal course and scalp distribution of the main effects of previous occurrence and emotionality observed across the entire ERP, profile comparisons were done on waveform areas in successive 100 ms intervals from stimulus onset at 0 ms to 1600 ms following onset. Topographical maps were based on correct trials only. To isolate the neural activity associated with these main effects over and above the neural activity associated with word evaluation, difference waveforms were derived by subtracting the ERPs to neutral foils from the ERPs to neutral studied words (Figure 4) and from emotional foils (Figure 5). Comparing the topographical maps in Figures 4 and 5 thus allowed for a comparison of the neural activity elicited by previous occurrence to that elicited by emotional salience.

In the scalp topographies for the neural activity associated with the effect of previous occurrence (Figure 4), the most positivity is noted from 500 to 700 ms following stimulus onset. This corresponds to the LPC noted in the ERP waveforms (Figures 1, 2 and 3). The scalp topographies reveal that this late positivity is localized in left frontal and central regions from 500 to 600 ms and then shifts to a more bilateral frontal positivity from 600 to 700 ms. During this latter interval, greater relative positivity is noted in the right hemisphere, although there is a slightly increased area of positivity in the left temporal-parietal region which is maintained until 900 ms following stimulus onset. Inspection of the scalp topographies indicates that the absence of the left parietal effect noted in statistical analyses of mean LPC amplitude was due to the presence of a larger area of positivity in right temporal-parietal regions from approximately 600 ms to 900 ms following word onset. A trend for a right frontal effect was noted in statistical analyses. Inspection of the scalp topographies reveals a distinct right frontal-temporal positivity from 900 to 1000 ms following word onset. Thus, it appears that the right frontal effect occurred, but was later than anticipated. These topographical maps also illustrate the late negativity to previously studied words noted in analyses of the ERPs. An unanticipated early effect was noted in the first 100 ms following word onset. During this latency window there was a frontal negativity and posterior positivity. The negativity was maximal in right frontal regions, while the positivity was maximal in left parietal regions.

Figure 5 illustrates the scalp topographies associated with the neural activity elicited in response to emotionality. In contrast to the distinct regions of negativity and positivity noted in the scalp topographies to previously studied words, emotionality appears to have elicited a more general positive response that began early and was maintained across the scalp and across the entire ERP waveform. An unanticipated very early effect was also noted for emotion over and above simple word evaluation.

However. unlike the left posterior positivity noted for previous occurrence in the first 100 ms. emotionality was associated with a large right lateralized positivity during this latency window. This shifted to a more bilateral frontal positivity by 300 to 400 ms. The most positivity for studied words was noted from 500 to 700 ms following word onset. The scalp topographies to emotionality appear similar during these latency windows. although maximal positivity was distributed more posteriorly for emotional foils than for studied words. Following the LPC, previously studied words were associated with a steep negativity whereas emotionality elicited sustained positivity which increased frontally from 1000 to 1300 ms following word onset.

Discussion

Behavioural Data

These data indicate that the salience induced by emotion produces similar response tendencies as have been observed for repeated words in previous research (e.g., Dywan et al., 1998), in terms of both behavioural and electrophysiological response. Behaviourally, participants were more likely to mistake new emotional foils for study words in comparison to new neutral words. The work of Whittlesea and colleagues (e.g., Whittlesea et al., 1990; Whittlesea, 1993; Whittlesea & Williams, 1998) indicates that processing fluency can have an impact on the experience of remembering. The results of experiment 1 suggest that the emotional salience of stimuli may also affect judgements about previous experience. As found in previous research with fluently processed stimuli, in this experiment, emotionally salient stimuli were more likely to be called "old" than were neutral stimuli, regardless of whether they had been previously studied or not. These data suggest that the experience of familiarity can be influenced by factors other than previous occurrence.

ERP Data

The effect of emotionality was also seen in the ERP response, with increased LPC amplitude for emotional words regardless of whether they had been studied or not. Observations of the LPC indicate that both previous occurrence and emotionality affected the amplitude of the ERP response. When anterior and posterior sites are included in the same analyses, the amplitude shift to emotional words is the most statistically reliable overall. These findings indicate that even within a recognition paradigm, the LPC cannot be interpreted as a specific index of recollection. Nevertheless, the ERP response to emotionality is not identical to the response based on previous occurrence.

Inspection of the temporal sequence of the scalp topographies revealed one region in which the neural response to previous occurrence and emotionality coincided with regards to timing but not scalp distribution. Both types of stimuli elicited positivity across the entire scalp from 500 to 700 ms following word onset although maximal positivity was distributed in a posterior fashion for emotional foils and in a frontal-central fashion for previously studied words. Given that response times were typically around 900 ms, the latency window from 500 to 700 ms likely reflects neural processes involved in response selection. At the time of response selection both previously studied words and emotional foils elicited increased positivity. Given the task context, the arousal engendered by emotionality may have been misinterpreted as familiarity, leading to the observed increased frequency of source errors to emotional foils.

During the LPC, from 400 to 800 ms after stimulus onset, the effect of emotionality is greatest at posterior sites whereas the effect of previous occurrence is greatest at frontal sites. In fact, the ERPs related to previous occurrence replicate the right frontal maxima shown in a number of previous studies in which participants were asked to discriminate between sources of previous occurrence (e.g., Johnson et al., 1997a). In contrast to previous studies of recognition, the anticipated left parietal old/new effect (e.g., Tendolkar & Rugg, 1998) was not supported in the present study. These findings are similar to those recently observed by Johnson et al. (1997b) in which differences between old and new words was greatest at frontal sites whereas there was little difference at posterior sites. According to Johnson et al. (1997b) the activity in the right frontal region may be associated with the reflective activity involved in retrieval and evaluation, whereas the activity at parietal sites may relate to the processing of the perceptual details (e.g., visual detail) of the items being reflected upon.

It is not clear, however, how much emphasis to place on the right frontal effect observed in these data for previous occurrence, as there is a general trend toward greater right hemisphere positivity in the ERPs elicited by both previous occurrence and emotionality. In addition, in this study as well as in others, previous occurrence is confounded with targetness. That is, responding "yes" to previously studied items is the task goal. Thus, the discrimination observed at frontal sites could also reflect the controlled neural processes associated with target discrimination. In contrast, stimulus emotionality appears to be reflected in a general and more diffuse posterior positivity. This may represent the more automatic neural response to the salience of emotional stimuli.

Emotionality and previous occurrence (or targetness) were further distinguished in the second latency window. Here, previous occurrence produced the greatest amplitude shift but in this case it was towards a significantly greater negativity for previously seen words and was maximal in the left posterior region. Although this effect may be due to the targetness of studied words as opposed to the previous occurrence *per se*, it is clearly distinct from the ERP effect seen for emotional words. Emotional words, on the other hand, maintain a relative positivity during this latency window, which is similar to very late ERP effects of emotion observed by Erhan et al. (1998).

Viewed over the entire recording epoch, previous occurrence produced the expected right frontal positivity during the LPC from 400 to 800 ms as well as a later right frontal-temporal positivity from 900-1000 ms. Emotionality, on the other hand, elicited a more posteriorly based positivity during the LPC. A right lateralized effect of emotionality was observed in the first latency window, which then became more generally distributed across the scalp and was maintained throughout the entire 1800 ms of the recording epoch. In summary, the neural response to emotionality in this study was more pervasive and more generally distributed than the neural response to targeted items, which was more focussed and controlled. The general positivity to emotion seems to be most strongly represented in posterior regions during the LPC and in frontal regions during later portions of the waveform, whereas the controlled process of recollection/target selection seem to be initiated frontally and resolve into a more dramatic late negativity.

Theoretical and Methodological Considerations

The observed effects clearly indicate that salience induced by something other than previous experience can affect both mnemonic decisions and electrophysiological responsivity within the context of a memory task. What is not so clear, however, is whether the effects are due solely to the influence of emotionality or whether the effects may have been due, at least in part, to the impact of a categorical distinction. Participants may have formed an impression of emotional study words as a separate category and membership in this category might have been responsible for their responsivity at test. That is, participants may have used the emotion "category" as a response criterion when performing the source monitoring task.

There are a number of reasons to suggest that category was not, in fact, used as a response criterion at test. Previous research indicates that emotional stimuli elicit increased ERP responses in a variety of paradigms, even when categorical distinctions would have been very unlikely (e.g., Kostandov & Arzumanov, 1986). In addition, participants could only have used "category" as a response criterion at test if they had developed such a criterion during the study phase of the task, and there are three reasons why this was not expected. First, the emotional words selected for the lists are not clearly semantically related, thus decreasing the likelihood of being readily classified or categorized in a way that other categories of words might be. For example, the words, "carrot", "potato" and "turnip" all clearly belong to one semantic category. In contrast, the words, "cancer", "anger", and "betray" are not readily classified as belonging to the same category. Second, although blocked presentation of emotional words would have been expected to increase false alarms (Roediger, 1996), the display study list words was arranged to purposely avoid blocked presentation of emotional words by having them appear interspersed with an equal number of unrelated neutral words. Third, participants were not directed to make any semantic judgement or elaboration, but to simply look at each word and try and remember it. Finally, there is anecdotal evidence in support of the assumption that a categorical distinction was not made. During debriefing, participants were asked to describe their perception of the purpose of the experiment; not one reported an awareness of any categorical distinction.

Given these methodological constraints and anecdotal evidence to the contrary, it is unlikely that participants spontaneously categorized words at study based on emotionality. Nevertheless, it is possible that over the course of study item presentation, participants may have formed some impression, possibly an implicit impression, of a categorical distinction for study words. As such, the source monitoring task was modified in experiment 2 to address this issue.

EXPERIMENT 2

The second experiment in this series was designed to compare and contrast the effects of "emotion" with those of "category" in the context of a source monitoring task very similar to that used in experiment 1. In order to directly compare the effects of "category" with those of "emotion", a second, more obvious, category of animal words was included. In addition, to decrease the likelihood that participants would form a categorical distinction at study, the proportion of emotional words in the study list was decreased from 50% to 20%. The revised study list was composed of 6 (20%) animal words (e.g., buffalo, kitten, beaver), 6 (20%) emotional words (e.g., death, blame, horror) and 18 (60%) neutral words (e.g., anthem, bucket, nudge) for a total of 30 study words. At test, the 30 study words were then presented interspersed in a pseudo-random fashion with 30 animal foils, 30 emotional foils and 180 neutral foils. Participants were asked to distinguish by key press whether each word was from the study list or not. If emotion is a potent source of salience above and beyond an effect due to "category", significantly more source errors, and significantly greater LPC amplitude, would be expected for emotional foils in comparison to both animal foils and neutral foils.

Method

Participants

Fourteen healthy young adults were paid for their participation. Data from one individual (female) were eliminated from analyses as she was unable to remain alert during the testing session. Thus, the young group was composed of 13 young adults (7 males) ranging in age from 17 to 25 (M = 20.77, SD = 1.88). All participants were Brock University undergraduate students (with the exception of one female grade 12 high school student working as a Co-Op student in the Brock Electrophysiology Lab), with a mean of 14.62 years (SD = 1.45) of completed formal education.

Materials

Materials were identical to those used in experiment 1 except that new study and test lists were used for the source monitoring task, the construction of which is described below.

Word Ratings

In order to ascertain that the words considered "neutral", "emotional" and "animal" would indeed be perceived as such by participants, word ratings were obtained prior to the construction of the lists for experiment 2 (see Appendix C-1 for details). A total of 350 words were rated twice by 15 participants. On a scale from 0 (not at all) to 6 (most), participants sorted words according to how much like an animal or how emotional they considered each word to be. Mean "emotionality" and "animalness" ratings were calculated for all words. Words rated as both highly emotional and highly animal-like (e.g., snake) were eliminated. Emotional and animal words were selected for inclusion in the lists based on a mean rating of 3.25 or greater. Neutral words were selected if they had ratings below 2.5 in terms of both "emotionality" and "animalness" (see Appendix C-2 to C-4 for ratings and sets of words used in the lists).

Source Monitoring Task. The study and test lists employed in this experiment included neutral, emotional and animal words, between 4 and 7 letters in length and matched for frequency in the English language (Kucera & Francis, 1967). The 30-item study list was composed of 18 neutral words, 6 emotional words, and 6 animal words, randomly distributed throughout the list. The test list was composed of the 30 study words and 260 new words (30 emotional foils, 30 animal foils, 180 neutral foils, and 10 neutral filler words inserted at the beginning of the test list), for a total of 290 words. Responses to the filler words were not used in calculating scores; they were included simply to allow participants time to orient themselves to the requirements of the source monitoring task, and control for a possible recency effect for words from the study list. The four types of words were distributed in the test list in a semi-randomized fashion in order to prevent successive presentation of multiple study and/or emotional or animal foil words. To control for responses being attributed to a particular group of words, six different versions of study and test lists were composed. Words used as study in list 1 become foils in list 2 and the words used as foils in list 2 become study words in list 3 and so on. Study and test lists were matched for the degree of emotional, animal and neutral content (see Appendix C-2 to C-4). List order was counterbalanced across participants.

Words were presented one at a time on a computer monitor (black letters with proportional spacing on white background). At study, words were presented for 2000 ms with 4000 ms inter-trial interval. At test, words were presented for 500 ms each with a variable inter-trial interval between 3000 and 4000 ms. Stimuli subtended a vertical angle of 0.4 - 0.5 degrees and a horizontal angle of 2.1 - 4.2 degrees, depending on the length of the word and slight differences in the distance between the participant's eyes and the monitor.

Electrophysiological Recordings

During the study and test phases of the source monitoring task, ERPs were recorded from 17 cap-mounted tin electrodes (Fz, Cz, Pz, F3, F4, F7, F8, C3, C4, T3, T4, T5, T6, P3, P4, O1, O2) using the International 10-20 system of electrode placement (Jasper, 1958), with right ear reference and mastoid ground. The left ear was recorded as a channel and data were rereferenced offline to an average of the two ears. Horizontal and vertical eye movements were recorded from electrodes attached to the supraocular and outer canthus of the right eye, and were used for ocular artifact rejection. The EEG and EOG were amplified by a gain of 40 000 with a 12 bit sensitivity window of ± 250 μV. Impedences were established at below 5 kOhms.

Procedure

Testing procedure was explained and each participant gave written informed consent. All testing was conducted individually in a single testing session (2.5 to 3 hours) with the same female examiner. Testing took place in a noise-free environment within the Brock Electrophysiology Lab. Participants completed the WAIS-R vocabulary and digit symbol sub-tests, and Brock Health-History Questionnaire. ERPs were recorded while participants performed the study and test phases of the source monitoring task[3]. During presentation of the study list, participants were instructed "Please sit quietly. Look at each word carefully and try and remember it, so that you would recognize it if you see it again a little later on". The test list was presented following a brief, distraction-filled delay of approximately 4 minutes, during which time the examiner gave instructions for the subsequent aspect of the task. Participants were then instructed "Now you will see a new list of words that is much longer than the one you just studied. On it you will see words from the study list along with many more new words that you haven't seen yet today". They were asked to use their dominant hand to press one key on the computer keyboard if they recognized the word from the study list and another key if they thought the word was new (*e* or *f* key for left handers and *i* or *j* key for right handers). Response keys were counter-balanced across participants.

Once it was clear that participants understood the instructions, stimulus presentation and recording of electrophysiological responses were initiated by the examiner. Immediately after completion of the source monitoring task, participants completed the paper and pencil recognition test for words from the study list, followed by the Beck Depression Inventory. Electrophysiological monitoring equipment was removed. Participants were asked for their impressions of the purpose of the experiment, and their responses were recorded by the examiner. Finally, participants were debriefed and thanked for their help.

[3] Although ERPs were recorded during the study phase, these data were not the focus of the present investigation and so were not analysed.

Results

Behavioural Data

Table 4 indicates the proportions of items designated "study" for each word category (study words, emotional, animal and neutral foil words). Source error is represented by the proportion of foil words incorrectly designated "study" at test. Because they were not previously seen in the experimental context, source errors for foil words represent illusions of remembering.

TABLE 4

Proportion of Test Words Judged to be from the Study List in Experiment 2

Word Type	**Mean Proportion (SD)**		**Reaction Time (SD) (milliseconds)**	
Study Word	.69	(.15)	959	(188)
Emotional Foil	.19	(.14)	1037	(391)
Animal Foil	.13	(.12)	990	(350)
Neutral Foil	.12	(.09)	970	(364)

Proportion of words designated "study" at test was the dependent variable in a repeated-measures ANOVA, with word type (study, emotional foil, animal foil, neutral foil) as the independent factor (see ANOVA Table, Appendix A-7). There was a significant main effect of word type on the tendency to designate a word as "study", $\underline{F}$ $(2.01, 24.17) = 110.25$, $p < .001$, $\eta^2 = .90$. As expected, previously studied words were significantly more likely to be identified as "study" at test then were all foils. Bonferroni corrected multiple comparisons revealed a significant difference between source errors to emotional versus neutral foils. In addition, planned comparisons revealed that participants made significantly more source errors for emotional foils in comparison to neutral foils, t (12) = 3.75, p = .003 and in comparison to animal foils, t (12) = 2.54, p = .026. There was no difference in the proportion of source errors made for animal and neutral foils. There were no differences in reaction time on correct trials for the four different types of list words, F (2.24,25.71) = .859, p = .471, η^2 = .07.

Correlation among behavioural measures

Simple Pearson product moment correlation coefficients (*r*) were calculated to assess the relations among variables (see Table 5). Again, it was hypothesized that differences in vocabulary, general attention, and depressed mood might account for some of the variance in measures of source monitoring. The relations of interest are discussed below. As was done in experiment 1, the general response tendency to make a false positive response during the source monitoring and post-test recognition was controlled, and residual scores for proportion of study word hits, emotional false positives, animal false positives and post-test recognition hits were used in correlation analyses.

TABLE 5

Simple Correlation of Behavioural Measures in Experiment 2

	SH	ESE	ASE	NSE	Rec
Recognition	.47	-.22	-.05	-.36	----
Vocabulary	.04	.35	.31	.32	.05
Digit-Sym.	.04	-.19	-.36	-.11	.27
BDI	.19	.41	.23	.62*	-.39

Note: SH = study word hits; ESE = emotional foil source error; ASE = animal foil source error; NSE = neutral foil source error; Rec. = recognition on paper. * Correlation significant at p<.05.

Study word recognition test

Memory for the study words was verified with a paper and pencil recognition test following completion of the running recognition task. Participants recognized a mean proportion of .65 (SD = .18) of the study words, indicating good memory for the study list. Participants made very few false positive responses at recognition (M = .03, SD = .04), indicating good discriminability. In this sample of young adults, after controlling for the general tendency to make false positive responses, the proportion of study words recognized following the source monitoring test was not significantly correlated with any other behavioural measure.

Vocabulary (WAIS-R)

Participants obtained a mean raw vocabulary score of 53.5 (SD = 5.1). Scaled scores were calculated based on the age of each participant. A mean age scaled score of 11.2 (S.D. = 1.3) was obtained, indicating that all participants performed within normal limits on this measure. There were no significant correlations between raw vocabulary score and any of the other behavioural measures. This indicates that general vocabulary ability did not have a significant impact on verbal memory discriminations in this sample.

Digit symbol (WAIS-R)

A mean raw digit-symbol score of 67.3 (SD = 6.6) was obtained, with a mean age corrected scaled score of 11.9 (S.D. = 1.5). All participants performed within normal limits on this measure of general attention. Digit-symbol raw score did not correlate significantly with any other behavioural measures in this sample.

Beck Depression Inventory

Overall, this sample of young adults obtained a mean BDI score of 5.62 (S.D. = 4.48), indicating in general, a very mild level of depressive symptoms (Beck et al., 1988). Scores ranged from 1 indicating virtually no depressive symptoms to 14 indicating moderate depressive symptoms. In this sample, BDI score was significantly correlated with the frequency of source errors to neutral foils ($r = .62$, $p<.05$), indicating that as severity of depression increased the tendency to make source errors in general also increased. After controlling for this general response bias, BDI score was not significantly correlated with the frequency of source errors to either emotional ($r = .41$) or animal ($r = .23$) foils. Unlike in experiment 1, in this sample, BDI score was not significantly correlated with the proportion of studied words correctly identified at test, suggesting that this relation is not very stable in this young, healthy population.

ERP Responses

General Observation

Grand average ERP waveforms based on correct trials (i.e., hits or correct rejections) for study words and three types of foil words (emotional, animal and neutral) are shown for all 17 electrode sites in Figure 6. Visual inspection of the waveforms revealed four distinct ERP components: component 1, 0-150 ms; component 2, 150-500 ms; component 3, 450-850 ms; and component 4, 1000-1300 ms post stimulus onset. As seen in Figure 6, the two earlier components appear to reflect an effect of emotional salience on ERP amplitude. Across all sites, during the first two components, a more positive amplitude response was consistently generated in response to emotional foils in comparison to both animal and neutral foils. In addition, at virtually all sites across the scalp, the waveform to emotional foils in the first two components was more prominent than that to studied target words. The third component observed here clearly corresponds to the late positive component (LPC). This effect replicates that of previous occurrence found in experiment 1, and is commonly observed in the context of memory tasks.

As observed in experiment 1, during the later portion of the waveform from 1000 to 1300 ms post stimulus onset, a different distinction between emotional salience and previous occurrence is noted. In this very late component, the relative positivity to emotional salience noted in the second component was maintained, as the waveform for emotional foils is the most positive waveform across most sites. In contrast, the positive amplitude shift to studied items that occurred during the latency window from 450 to 850 ms after onset declines dramatically into a late negativity in the region from 1000 to 1300 ms post stimulus onset. This effect was most pronounced at central and posterior sites.

Area under the curve for these four components formed mean amplitudes, based on correct trials only, for each word category: studied words, emotional foils, animal foils and neutral. These mean amplitudes were entered into separate repeated-measures analyses of variance (ANOVA) at midline (Figure 7) and lateral (Figure 8) sites, to address two main hypotheses. Hypothesis one was that emotional foils would elicit a more positive ERP amplitude shift relative to both animal and neutral foils. Hypothesis two was that previously studied words would be associated with the most positive amplitude shift during the LPC. It is important to note, however, that in this experiment, previous occurrence was confounded by the inclusion of 6 emotional and 6 animal target words. Thus, any effects cannot be attributed to previous occurrence alone, but may have been influenced to some degree by the aforementioned sources of salience, as well as by a "targetness" effect. Thus, when comparing the effects of "emotionality" and "animalness", only emotional and animal foils were included in the analyses. As in experiment 1, results of lateral sites analyses were of primary interest here. Therefore, midline data will be presented only when it adds novel information to the interpretation of effects.

Early Component 1 (0-150 ms post onset)

Distinct ERP differences were not anticipated for this very early area of the waveform. However, visual inspection of the ERP waveforms (see Figures 6, 7 and 8) revealed a consistent positive going amplitude shift across all sites for emotional foils. Although earlier than expected, this difference appeared to distinguish emotional from animal foils, as predicted by hypothesis one. To test the statistical reliability of this difference, mean component 1 amplitude was obtained for emotional and animal foils at all 17 sites (see Appendix B-3). Word category, lateral plane and sagittal plane and/or site, then served as within-subject factors in separate repeated-measures ANOVAs on data from lateral and midline sites. As in experiment 1, the analyses of lateral sites were of primary interest and results of midline analyses are only presented when they add to the interpretation of the results at lateral sites. Also as in experiment 1, when an ANOVA gave rise to a significant interaction, the ANOVA was repeated with data normalized using a scaling procedure (McCarthy & Wood, 1985; Ruchkin, Johnson & Friedman, 1999). In these and all other analyses reported here, if necessary, F ratios are reported with degrees of freedom adjusted by the Huynh-Feldt procedure to correct for nonsphericity.

A 2x2x2 within-subject repeated-measures ANOVA was conducted on component 1 amplitude at lateral sites (F3, F4, P3, P4), with word category (emotional vs. animal foil), lateral plane (left vs. right) and sagittal plane (frontal vs. posterior) as the within-subject factors (see ANOVA Table, Appendix A-8). As illustrated, ERP waveforms of emotional foils (Figure 8) were associated with more positive neural activity during this latency window. There was a significant main effect of word category, $\underline{F}$ (1,12) = 8.40, p = .013, η^2 = .41. The mean component 1 amplitude to emotional foils (M = 0.71 μV) was greater than that observed for animal foils (M = -0.52 μV). There was no main effect of site, nor an interaction. However, there was a trend for an effect of the sagittal factor (p = .08), indicating greater overall positivity at parietal (M = 0.31 μV) than at frontal (M = -0.12 μV) sites.

Component 2 (150-500 ms)

Mean component 2 amplitude for correctly rejected emotional and animal foil words (see Appendix B-4) was compared during the portion of the waveform from 150 to 500 ms post stimulus. Repeated-measures ANOVA at lateral sites revealed a significant main effect of sagittal plane on component 2 amplitude, $\underline{F}$ (1,12) = 25.96, p < .001, η^2 = .68. Regardless of word category, a more positive component 2 amplitude was found at posterior (M = 2.99 μV) compared to frontal (M = 0.36 μV) regions. Although there was greater positivity to emotional foils (M = 2.60 μV) than animal foils (M = 0.74 μV), this difference was not statistically reliable. There was also a trend for an interaction between word category, lateral plane and sagittal plane, with the greatest positivity noted for emotional foils at the left parietal (M = 4.09 μV) site (see ANOVA Table, Appendix A-9).

Component 3 (LPC, 450 – 850 ms)

Mean LPC amplitude was obtained for each word category (see Appendix B-5). Repeated-measures ANOVAs were conducted on LPC amplitude, with word category (studied word, emotional foil, animal foil and neutral foil), lateral plane (left vs. right) and sagittal plane (frontal vs. posterior) as the within-subject factors (see ANOVA Table, Appendix A-10). There was a significant main effect of word category on LPC amplitude, $\underline{F}$ (3, 36) = 12.66, p <.001, η^2 = .51. The most positive LPC amplitude shift occurred for previously studied words (M = 5.23 μV) relative to all categories of foils (emotional M = 0.92 μV; animal M = 0.77 μV; neutral M = 0.84 μV). There was also a significant main effect of sagittal plane, $\underline{F}$(1,12) = 11.83, p = .005, η^2 = .50, with a more positive mean amplitude shift in the posterior (M = 2.94 μV) versus the frontal (M = 0.94 μV) region.

Additional comparisons restricted to frontal and parietal electrodes were carried out to test for the anticipated right frontal source monitoring effect and the left parietal old/new effect (see ANOVA Table Appendix A-11). There was a trend for a right frontal effect, F (1,12) = 3.32, p = .09, η^2 = .22, as right frontal activity was more positive (M = 1.2 μV) than left frontal activity (M = 0.68 μV). There was also a main effect of word category at frontal sites, $\underline{F}$ (3,36) = 8.74, p <.001, η^2 = .42. As seen when all lateral sites were included in the analysis, greatest positivity was found for previously studied words

(M = 3.79 μV) in comparison to all categories of foils (emotional M = -0.01 μV: animal M = -0.30 μV; neutral M = 0.29 μV). There was no interaction.

Analyses restricted to parietal sites failed to reveal evidence for the expected left parietal old/new effect (see ANOVA Table Appendix A-12). Mean amplitude in the left parietal region (M = 3.0 μV) did not differ from that in the right parietal region (M = 2.9 μV), $\underline{F}$ (1,12) = 0.42, ns. There was a main effect of word category at parietal sites. $\underline{F}$ (3,36) = 13.1, p <.001, η^2 = .52. As noted in other analyses of lateral sites, the most positive LPC amplitude shift was observed for previously studied words (M = 6.67 μV) in comparison to all categories of foils (emotional M = 1.85 μV; animal M = 1.83 μV: neutral M = 1.40 μV). There was no interaction.

Component 4 (1000 – 1300 ms)

Across all 17 sites, this very late portion of the waveform was characterized by sustained positivity to emotional foils in contrast to a dramatic negative going amplitude shift for previously studied words. Mean amplitude for each word category for this latency window was obtained for all 17 sites (see Appendix B-6). Repeated-measures ANOVA at lateral sites (F3, F4, P3, P4), revealed a main effect of word type, $\underline{F}$ (1,12) = 6.64, p = .024, η^2 = .36 on component 4 amplitude (see ANOVA Table, Appendix A-13). During this latency window, greater overall positivity was observed for emotional foils (M = 1.46 μV) than studied words (M = -1.08 μV). There was a significant main effect of lateral plane, $\underline{F}$(1,12) = 7.46, p = .018, η^2 = .38, with more positive neural activity in the right (M = 0.67 μV) versus the left (M = -0.30 μV) hemisphere. There was a significant main effect of sagittal plane, $F(1,12) = 31.25$, $p < .001$, $\eta^2 = .72$, indicating relatively more positive neural activity in frontal (M = 1.86 μV) versus posterior (M = -1.48 μV) regions. There was also a significant interaction between lateral and sagittal planes, $F(1,12) = 6.85$, $p = .022$, $\eta^2 = .36$. For both word categories, there was a significant negative amplitude shift from frontal to parietal regions in both left, $t(12) = 6.41$, $p < .001$, and right hemispheres, $t(12) = 4.79$, $p < .001$. Within both hemispheres, there was greater positivity in frontal regions (left M = 2.04 μV; right M = 2.19 μV) than posterior regions (left M = -1.92 μV; right M = -0.43 μV). There was also a significant between-hemisphere difference at parietal sites, $t(12) = -4.03$, $p = .002$, with a larger negative deflection in the left (M = -2.3 μV) as opposed to the right (M = -0.66 μV) hemisphere.

Temporal Sequence of Topographical Distributions

To provide additional information on the temporal course of the main effects and interactions observed in analyses of ERPs at the four areas under the curve, profile comparisons were done on waveform areas in successive 100 ms intervals from stimulus onset at 0 ms to 1600 ms following onset. Topographical maps were based on correct trials only. To isolate the neural activity associated with the main effects of each word condition, from the neural activity associated with word evaluation, difference waveforms were derived by subtracting the ERPs neutral foils from the ERPs to studied words (Figure 9), from ERPs to emotional foils (Figure 10) and from ERPs to animal foils (Figure 11). These topographical maps allowed for an inspection of the temporal course of target recognition processes. In addition, of primary interest with regard to the purpose of this experiment, differences in neural activity specific to emotionality were directly compared to the neural activity associated with a category effect.

Scalp topographies representing the neural activity associated with processing previously studied words were characterized by maximal positivity during the latency window corresponding to the LPC followed by a late negativity, similar to the pattern seen in experiment 1. In this sample, posterior positivity with a right lateralized focus was noted in the early portions of the recording epoch, from 100 to 200 and 300 to 400 ms after word onset. This spread to a more generalized positivity from 400 to 900 ms, with virtually no indication of a right frontal or left parietal effect. A small area of relatively greater positivity was noted from 900 to 1000 ms after word onset in the left temporal region. Of note, in this sample the late positivity was maintained for a longer amount of time than was seen in experiment 1 (500 to 700 ms). This difference was likely due to the fact that words were on the screen longer at test in experiment 2. The late negativity for previously studied words noted in statistical analyses is also evident in the scalp topographies from 1000 ms after word onset until the end of the recording epoch.

The scalp topographies for neural responses elicited by emotionality and the categorical effect of "animalness" were distinguished throughout the entire temporal sequence. In general, emotionality was characterized by positivity in virtually every interval, animal foils were associated with negativity in virtually every 100 ms interval. Emotionality elicited a positive response that began immediately following word onset, which was maximal from 100 ms to 500 ms following word onset, as noted in the statistical analyses. This positivity was generally distributed across the scalp with maximal positivity in the right frontal region from onset to 100 ms, shifting to a central posterior maximal positivity from 100 to 600 ms after word onset. The most notable region of negativity elicited by emotionality occurred from 600 to 700 ms. In contrast, it was during this latency window that animal foils were associated with the most positivity relative to the rest of the recording epoch for that category. This positivity was localized a central-posterior fashion and was maintained to a lesser degree until 800 ms following word onset. Following this, the neural response to animal foils declined into a late negativity from 800 to 1400 ms whereas the neural response to emotionality was generally positive throughout.

Discussion

Behavioural Data

Experiment 2 was designed to assess the extent to which the effects of emotionality on both mnemonic decisions and ERPs observed in experiment 1 might have been due to a categorical effect, rather than to an effect of emotion *per se*. To do this, animal words were added to the source monitoring task in experiment 2. This paradigm permitted a direct comparison of the impact of emotional salience and a non-emotional category on both mnemonic decisions and ERPs within the same participants in the same test session. Thus, it was anticipated that if emotion is indeed a potent source of salience, this would be seen in terms of increased ERP amplitude and increased frequency of source errors for emotional foils in comparison to animal foils. In addition, it was expected that previously studied words would elicit the typical late positive ERP amplitude known as the LPC.

The results of this experiment suggest that emotion may indeed have some impact above and beyond that of a category effect alone. The impact of emotionality is most evident behaviourally, as participants were almost twice as likely to mistake previously unseen emotional foils as being from the study list in comparison to animal and neutral foils, which did not differ in error rates.

ERP Data

The difference between emotional and animal foils noted in the behavioural data is also evident in the electrophysiological results. As illustrated in the scalp topographies to emotionality and categorical effects (Figures 10 and 11, respectively), emotional foils elicited a positive neural response whereas animal foils were associated with a general negativity during the first 500 ms of the recording epoch. This difference was observed in the ERP waveforms for emotional and animal foils across all sites, which was significant in a very early portion of the waveform, from 0 to 150 ms after stimulus onset. It appears that extremely early on in the recording epoch, participants made a distinction of some kind between the two categories of foil words. A possible interpretation of this early distinction would be that it is an index of attentional selection, that stage in processing at which some inputs are selected for further attention and others are suppressed (Luck & Girelli, 1998). This interpretation will be considered at a later point in this discussion. For now it is important to note that this early reactivity to emotional foils was maintained throughout the recording epoch. In all latency windows, emotional foils consistently elicited more positive ERP amplitude than animal foils. Together, the behavioural and ERP results indicate that emotionality does have some impact above and beyond that due to a categorical effect alone.

As anticipated, increased LPC amplitude was elicited by previously studied words relative to new words. This positive amplitude shift to words previously studied in the experimental context replicates the findings of experiment 1 as well as those in previous research described in the ERP and memory literature. (Although the LPC to previously studied words in this experiment was confounded by possible influences of categorical and emotional effects, as well as by the "targetness" of the previously studied words.) However, in addition, increased ERP amplitude was found for emotionally salient new information. As found in experiment 1, reactivity to emotionality was associated with increased frequency of source errors to emotional foils. These results support the hypothesis that the neural response may serve as a general cue that an item is important.

Interpretation of why a stimulus seems important appears to depend on the goals of the participant within the context in which the reactivity occurs.

During the LPC, a trend toward greater right frontal positivity to previously studied words (the right frontal effect) was evident, however, there was no evidence for the left parietal old/new effect. These findings concur with those of experiment 1, as well as similar effects observed by Johnson et al. (1997b). The left parietal effect consisting of increased LPC positivity in the left as opposed to right parietal regions is frequently found in ERPs to recollected items and so is considered an index of memory retrieval of recently encoded episodes (Tendolkar & Rugg, 1997). The fact that this effect was not observed for recollected items in the present 2 experiments is further support for the lack of specificity of the LPC as an index of recollection, *per se*. The right frontal activity observed here may represent the underlying neural activity associated with the reflective process involved in the evaluation of stimulus salience relative to the task at hand. Such processes would likely involve comparing the neural response elicited by test stimuli to memory representations of those stimuli in determining goal relevance.

<u>Component 1 emotion effect: Evidence of early selection?</u>

Although most researchers agree that attention acts to select some information for further processing and reject other stimuli, there is a long-standing debate with regards to the exact nature of the selection process. A comprehensive discussion of this debate is beyond the realm of this paper. Briefly, the concern relates to whether selection occurs early or later on in the stream of information processing. Those in support of early selection argue that the perceptual processing capacity of the human brain is finite;

therefore, attention operates early on to direct processing towards relevant stimuli. On the other side of the debate, those in favour of late selection propose that the limitations in human processing capacity occur much later than the perceptual level. They argue that attention operates at a later stage to weed out irrelevant stimuli from further processing in memory and response systems (Luck & Girelli, 1998).

ERPs have been used to provide direct evidence for the time line of attentional processes, and indicate that, at least in certain circumstances, attention does operate at a very early stage (see Luck & Girelli, 1998 for a review). Indeed, under conditions of high perceptual load, attention begins to influence processing within 20 ms of stimulus onset (e.g., Woldorff, Hansen & Hillyard, 1987). ERP studies of language processing typically focus on later portions of the waveform such as the N400, but by that point the eyes have already shifted on to the following word. In effect, the typically studied ERP effects occur after the response has already moved on.

According to Luck and Girelli (1998), if early selection has occurred, there must be some evidence of perceptual processing being degraded for ignored stimuli or enhanced for attended stimuli. In the present study, emotion appears to have resulted in enhanced processing. In comparison to other foils, emotional foils elicited increased positivity immediately following word onset, with the greatest distinction noted in the first 500ms following word onset. In addition, positivity to emotional foils was maintained late into the recording epoch, which has been considered an index of enhanced information processing (Erhan et al., 1998). Moreover, emotional foils were most likely to be mistaken for previously studied words. These findings suggest that perceptual processing of emotional foils was indeed enhanced relative to other foils.

This. in turn. supports the possibility that the early ERP distinction for emotion foils seen here in the first latency window may indeed be an index of early attentional selection.

ERP evidence of early selection attentional processes was not an anticipated outcome for the present study. Nevertheless. these findings provide important insight into the time line of attentional processes involved in source monitoring decisions. As is typical in the ERP and memory literature, the present analyses have been focussed on the late positive components of the ERP waveform as the region of most interest. However. perhaps it is also the case here that these late effects occur after some interesting effects have already occurred. For this reason. it will be important for further studies in this area to examine the very early responses immediately following stimulus onset.

EXPERIMENT 3

Experiment 1 was conducted with normal young adults in order to assess the feasibility of using emotional words to manipulate salience in the context of a source memory task. The results of that study indicated that emotion is a potent source of salience, as young adults were significantly more likely to "remember" studying not seen before emotional foils in comparison to neutral foils. This was also seen in the ERPs, as emotion had a significant impact on LPC amplitude almost identical to that seen for neutral studied words. Experiment 2 demonstrated that emotion does have some impact on mnemonic decisions and ERPs above and beyond the effects of a categorical effect alone. Together, the results of the first two experiments provide convincing support for the hypothesis that neural activity measured by ERPs may be more aptly considered an index of more salient relative to less salient information, rather than being viewed an index of recollection *per se*. In addition, these results obtained with young adults indicate that emotion is indeed a potent source of salience, such that manipulation of attentional capacity is not required to investigate the effects of emotion on source memory attributions.

Source error has been conceptualized as an attributional problem stemming from a reduction in attentional capacity (Dywan & Jacoby, 1990; Jacoby, Kelley & Dywan, 1989), and consequent reduced inhibitory efficiency (Dywan, Segalowitz, Henderson & Jacoby, 1993; Dywan et al., 1994; Dywan et al., 1998). Hasher and Zacks (1988) proposed that as people age, there is a decrease in the ability to inhibit information irrelevant to the task at hand. Given that "inhibition requires and consumes attentional resources" (Engle et al., 1995), when attentional capacity is decreased, the inhibitory process becomes more difficult. Mnemonic decisions are a product of both controlled and automatic processes. When controlled and automatic processes are in opposition, the extent to which an individual is able to inhibit automatic response tendencies appears to vary according to attentional capacity.

There is considerable evidence that older adults have more difficulty discriminating the sources of previously encountered information than young adults. For example, older adults are more likely to mistake previously read non-famous names (such as Sam Weisdorf) for famous names (such as Harry Truman) than are young adults (Dywan & Jacoby, 1990; Dywan, Segalowitz & Williamson, 1994; Jennings & Jacoby, 1993), and to confuse words rehearsed subvocally with words spoken aloud (Hashtroudi, Johnson & Chrosniak, 1989). There is general consensus that these kinds of source monitoring errors are linked to a decline in attentional control processes, typically associated with frontal lobe functioning (e.g., Craik, Morris & Loewan, 1990; Dywan & Jacoby, 1990; Moscovitch, 1994). However, there is no clear consensus with regards to exactly how frontal decline may lead to diminished source monitoring ability.

Based on the assumption that inhibitory control relies on attentional resources (Engle et al., 1995), it was hypothesized that the tendency to over-react to emotionally salient, yet task-irrelevant, information would be more pronounced in individuals with decreased attentional resources, in particular, the elderly. It was anticipated that older adults would show a much more positive ERP amplitude shift to salient, yet task irrelevant, emotional foils in comparison to other stimuli. In addition, older adults were expected to be more likely to mistakenly "remember" emotional foils as opposed to either animal or neutral foils.

Method

Participants

Healthy, community dwelling, older adults between the ages of 62 and 84 were recruited from the St. Catharines, Ontario, area through newspaper advertisements. Twenty-three older adults volunteered, and were reimbursed for any expenses that they incurred in order to participate. Seven individuals served as pilot subjects, to ensure that the source monitoring paradigm would not be too difficult or lengthy for older adults. Sixteen volunteers participated in experiment 3. Two cases (females) were eliminated due to excessive EEG artifact, and one (female, age 84) was eliminated due to an inability to complete the source monitoring task. Thus, the final sample of older adults comprised 13 individuals (6 males) ranging in age from 64 to 78 ($M = 72.69$, $SD = 4.71$), with a mean of 11.46 ($SD = 1.56$) years of completed formal education.

Materials and Procedure

Materials were identical to those used in experiment 2. Slight changes in procedure were made in order to accommodate a lengthened testing time and a midway break time for the older adults. Administration of tests was divided into two parts of approximately equal duration (approximately 1.5 to 2 hours each). Part 1 included the WAIS-R vocabulary and digit symbol sub-tests, Brock Health-History Questionnaire (administered by the examiner) and Beck Depression Inventory (self administered). There was a 15 - 20 minute break following completion of part 1, during which time participants chatted with the examiner and enjoyed some refreshments. Part 2 involved the application of the electrode cap, the source monitoring task, paper and pencil recognition test, and debriefing. All testing took place in a single testing session (approximately 3.5 to 4 hours) at the Brock Electrophysiology Lab with one of two examiners. Some of the older adults participated in pairs (with a spouse or friend). In those instances, two female examiners worked with the participants. One examiner administered part 1 of the testing with one participant, while the other examiner conducted part 2 of the testing with the other participant and then vice versa.

Results

Behavioural Data

Table 6 lists the proportions of items designated "study" for each word category (study words, emotional, animal and neutral foils). Source error is represented by the proportion of foils incorrectly designated "study" at test. Because these words were not previously seen in the experimental context, the tendency to "recognize" foil words represents an illusion of remembering.

TABLE 6

Proportion of Words Judged to be from the Study List
by Older Adults in Experiment 3

Word Type	**Mean Proportion (SD)**		**Reaction Time (SD) (milliseconds)**	
Study Words	.58	(.17)	1068	(187)
Emotional Foils	.12	(.09)	1085	(277)
Animal Foils	.21	(.15)	1059	(255)
Neutral Foils	.14	(.10)	1031	(279)

Proportion of words designated "study" at test was entered as the dependent variable in a repeated-measures ANOVA, with word type (study, emotional foil, animal foil, neutral foil) as the independent factor (see ANOVA Table, Appendix A-14). There was a significant main effect of word type on the tendency to designate a test word as "study", $\underline{F}$ (3,36) = 61.73, p <.001, η^2 = .84. As expected, previously studied words were significantly more likely to be identified as "study" at test, in comparison to all three types of foils. Planned comparisons revealed that older participants made significantly more source errors for animal foils in comparison to neutral foils, $\underline{t}$ (12) = 2.45, p = .031. There was no difference in the proportion of source errors made for emotional versus neutral foils, or for emotional versus animal foils. There were no differences in response time on correct trials for the four types of test list words. Response times of this sample of older adults did not differ from those of younger adults in experiment 2.

To assess the impact of aging on source decisions, the responses of older adults were compared to those of the sample of young adults tested under the same conditions in experiment 2. A mixed repeated-measures ANOVA was conducted with word category as the within-subject factor between age groups (see ANOVA Table, Appendix A-15). There was a main effect of word category on the probability of designating a word "study" at test, $\underline{F}$ (2.54, 60.9) = 164.02, p <.001, η^2 = .87. This indicates that both older and younger adults were likely to correctly designate previously studied words as such at test. There was also an interaction between word category and age group on the proportion of words designated "study" at test, $\underline{F}$(3,72) = 5.62, p = .002, η^2 = 19. Young adults made more source errors to emotional foils (M = .19) than either animal (M = .13) or neutral (M = .12) foils, while older adults made a higher proportion of source errors to animal foils (M = .22) in comparison to both emotional (M = .12) and neutral (M = .14) foils.

Correlation among behavioural measures

Simple Pearson product moment correlation coefficients (*r*) were calculated to assess the relations among variables (see Table 7). Again, it was hypothesized that differences in vocabulary, general attention, and mood might account for some of the variance in measures of source monitoring. The relationships of interest are discussed below. As done in experiments 1 and 2, the general response tendency to make a false positive response during source monitoring and post-test recognition was partialled out by regression, and residual scores were used when calculating correlations with the proportion of hits to study words, source errors to emotional foils, source errors to animal foils, and post-test recognition hits.

TABLE 7

Simple Correlation of Behavioural Measures for Older Adults in Experiment 3

	SH	ESE	ASE	NSE	Rec
Recognition	.21	.24	.42	-.28	----
Vocabulary	.62*	.19	.19	.06	.58*
Digit-Sym.	.55	-.07	.02	.17	.43
BDI	-.01	-.79**	.42	.40	-.30

Note: SH = study word hits; ESE = emotional foil source error; ASE = animal foil source error; NSE = neutral foil source error; Rec. = recognition on paper.

** Correlation significant at p<.001; * correlation significant at p<.05.

Study word recognition test

Memory for the study words was verified with a paper and pencil recognition test following completion of the running recognition task. Older adults correctly recognized a mean proportion of .75 (SD = .25) of the study words, indicating good recognition memory for the study list. The proportion of study words recognized on this test did not differ from that of younger adults. However, older adults made significantly more false positive responses (M = .23) than did young adults (M = .03), $t(24) = -4.51$, $p < .001$, indicating that older adults had more difficulty discriminating between previously studied and new words than did young adults. After controlling for the general tendency to make false positive responses, older adults' scores on this test were positively correlated with raw vocabulary score, indicating that those with better vocabulary recognized more words post-test. However, residuals of the post-test scores did not correlate with any other behavioural measure, indicating that differences in source monitoring were not accounted for by differences in memory for the study list *per se*.

Vocabulary (WAIS-R)

This sample of older adults obtained a mean raw score of 58.3 (SD = 10.1), which was slightly higher than the mean raw score of young adults (M = 53.46, SD = 5.06), although not significantly different. Scaled scores were calculated based on the age of each participant. However, since WAIS-R age scales have an upper age limit of 74, age scaled scores for participants over the age of 74 were based on comparison to a slightly younger normative sample. A mean age scaled score of 13.9 (S.D. = 2.8) was obtained, indicating that all participants performed within normal limits on this measure. When corrections for age were made, older adults obtained higher scaled vocabulary scores than did younger adults (M = 11.15), $t(24) = -3.13$, $p < .01$, indicating that even when compared to their same-age peers, this sample of older adults had better vocabulary skills than did the sample of young adults in experiment 2.

In this sample of older adults, raw vocabulary score was related to the proportion of study words responded to during the source monitoring task ($r = .62$, $p < .05$) as well as to the proportion of studied words identified post-test ($r = .58$, $p < .05$) These findings suggest that differences in vocabulary ability within this sample may have had some impact on verbal memory.

Digit symbol (WAIS-R)

Older adults obtained a mean raw score on this measure of 44.0 (SD = 11.3), which was significantly lower than that obtained by younger adults (M = 67.31, SD = 6.56), $t(24) = 6.42$, $p < .001$. However, when raw scores were corrected for age, performance of older adults (M = 12.7, S.D. = 3.0) did not differ from that of younger adults (M = 11.85, SD = 1.46). All older adults performed within normal limits for their age on this measure of general attention. Raw scores on this test were correlated with raw vocabulary scores ($r = .64$, $p < .05$), indicating a consistency in general cognitive abilities for this sample of older adults. Raw digit-symbol scores did not correlate with any other variable, however.

Beck Depression Inventory

Overall, this sample of older adults obtained a mean BDI score of 3.69 (S.D. = 2.69), indicating in general, a very mild level of depressive symptoms (Beck et al., 1988). Scores ranged from 0 to 9, indicating absent to mild levels of depressive symptomatology for the entire sample of older adults. On average, older adults were slightly less depressed than the sample of young adults (M = 5.62, SD = 4.48), however the difference was not significant. Among older adults, there was a significant negative correlation between BDI score and frequency of source errors to emotional foils ($r = -.79$, $p < .001$), once the frequency of source errors in general (i.e., to neutral foils) was controlled. The higher a participant's BDI score, the fewer source errors he or she made to emotional foils This relation suggests that perhaps the more depressed individuals had particularly better source discrimination for negatively valenced information. However, it would be difficult to argue that any of these older adults were seriously depressed.

ERP Responses

General Observation

Grand average ERP waveforms based on correct trials only (i.e., hits or correct rejectinos) for study words and three types of foil words (emotional. animal and neutral) are shown for all 17 electrode sites in Figure 12. Visual inspection of the waveforms revealed four ERP components: component 1, 0-150 ms; component 2, 150-700 ms: component 3, 650-1050 ms; and component 4. 800-1400 ms post stimulus onset. These components capture the peak amplitudes of the effects in this age group, and are analogous to the four components obtained for young adults in experiment 2. Thus, between-group analyses of ERP effects were performed on the areas under the curve in which the maximal amplitude was evident for each age group (see Mark & Rugg, 1998, Rugg et al., 1997 for similar treatment of ERPs from older and younger adults).

In contrast to the differences observed in young adults between the waveforms to emotional and animal foils in component 1, very little ERP activity was observed in this first latency window in older adults. There was also little distinction in the waveforms for the different word categories during the second component. However, beginning in the third component, the ERPs to animal foils become relatively the most positive waveform across virtually all sites. The late negative decline observed for studied words in young adults was also observed in this sample of older adults, although to a less dramatic extent. As best illustrated in Figure 14, the most notable effect consistently observed in the distribution of ERP waveforms was the slightly increased amplitude of the response to animal foils in comparison to all other word categories, whereas there was little distinction between emotional and neutral foils. This was not anticipated. The other notable effect in the ERPs elicited by all word categories was the increased positivity at anterior versus posterior sites. This waveform morphology contrasts with that of the young adults in experiments 1 and 2, in whom maximal positivity of ERP effects occurred at posterior sites.

Area under the curve for the four components formed mean amplitudes, based on correct trials only, for each word category: studied words, emotional foils, animal foils and neutral foils. These mean amplitudes were entered into separate within group repeated-measures analyses of variance (ANOVA) at both midline (Figure 13) and lateral (Figure 14) sites. However, given the literature on right frontal and left parietal effects associated with recognition memory and source memory decisions, analyses of lateral sites were of primary interest. Therefore, as was done in the first two experiments, results of midline analyses will be presented only if they add to the interpretation of the ERP effects for a given latency window. Between-group analyses were also conducted in a mixed-design, between-group format, in order to assess the effect of aging on ERP responses to stimuli in this paradigm. Significant between-group results and interactions with age group will be presented along with the description of the corresponding within-subject analyses. As in experiments 1 and 2, when an ANOVA gave rise to a significant interaction, the ANOVA was repeated with scaled data (McCarthy & Wood, 1985; Ruchkin, Johnson & Friedman, 1999). In these and all other analyses reported here, if necessary, $\underline{F}$ ratios are reported with degrees of freedom adjusted by the Huynh-Feldt procedure to correct for nonsphericity.

Component 1 (0-150 ms)

Mean component 1 amplitude was obtained for all sites and all word categories (see Appendix B-7). A 2x2x2 repeated-measures ANOVA was conducted on component 1 amplitude at lateral sites, with word category (emotional vs. animal foil). lateral plane (left vs. right hemisphere) and sagittal plane (frontal vs. posterior) as the within-subject factors (see ANOVA Table, Appendix A-16). There were no significant main effects. and the lateral- by sagittal-plane interaction was not significant when tested with scaled data. Despite the differences between emotional and animal foils noted for young adults in this latency window, there were no significant interactions with age group.

Component 2 (150-700 ms)

Areas under the curve for this latency window for emotional and animal foils (see Appendix B-8) were entered as dependent variables in repeated-measures ANOVAs at midline and lateral sites. A 2x2x2 repeated-measures ANOVA was conducted on component 2 amplitude at lateral sites (F3, F4, P3, P4), with word category (emotional vs. animal foil), lateral plane (left vs. right hemisphere) and sagittal plane (frontal vs. posterior) as the within-subject factors (see ANOVA Table, Appendix A-17). There was a main effect of sagittal plane, $\underline{F}(1,12) = 8.16$, $p = .014$, $\eta^2 = .41$. During this latency window, more positive ERP amplitude was found at frontal (M = 2.73 μV) than parietal (M = 1.25 μV) regions. There were no other main effects or interactions.

Interactions with age group were found in the ANOVA of component 2 amplitude from lateral sites (see ANOVA Table, Appendix A-18). There was a significant interaction between age group and word category, $\underline{F}(1,24) = 4.58$, $p = .04$, $\eta^2 = .16$.

Younger adults produced a significantly greater positive amplitude shift for the emotional (M = 2.60 μV) versus animal (M = 0.74 μV) foils, $t(12) = 1.89$, $p = .04$ (one tailed). In contrast, older adults did not produce significantly different amplitude in response to animal (M = 2.27 μV) versus emotional (M = 1.72 μV) foils. There was also an interaction between age group and sagittal plane, $F(1,24) = 31.55$, $p < .001$, $\eta^2 = .57$. Post-hoc analyses of this interaction confirmed that positivity was maximal frontally (M = 2.73 μV) as opposed to parietally (M = 1.25 μV) for older adults, $t(12) = 2.86$, $p = .01$. In contrast, young adults exhibited significantly more positivity in posterior (M = 2.99 μV) than frontal (M = 0.36 μV) regions, $t(12) = -5.10$, $p < .001$. In addition, the positivity produced at frontal sites by older adults was significantly more positive than that of young adults, $t(24) = 2.42$, $p = .02$ (two tailed). The four-way interaction was not significant when tested with scaled data.

Within the older age group, the ANOVA at midline sites revealed some effects not observed at lateral sites (see ANOVA Table, Appendix A-19). As noted in analysis at lateral sites, older adults produced greater positivity at the frontal midline site, Fz (M = 3.10 μV) compared to the central site, Cz (M = 0.78 μV) and posterior site, Pz (M = 1.29 μV), $F(2,24) = 14.80$, $p < .001$, $\eta^2 = .55$. However, at midline sites there was also a significant word category by site interaction, $F(1.46,17.46) = 4.08$, $p = .046$, $\eta^2 = .25$. As illustrated in the ERP waveforms (Figure 13), the overall neural response was most positive at Fz during this latency window, with equivalent amplitude shifts to emotional (M = 3.05 μV) and animal (M = 3.15 μV) foils. However, at Pz, the response to animal foils (M = 1.86 μV) was more positive than that to emotional foils (M = 0.71 μV), $t(12) =$

-2.28, $p = .04$. Emotional foils elicited the most positivity at Fz in comparison to both Cz ($M = 0.32$ μV), $t(12) = 5.66$, $p < .001$ and to Pz ($M = 0.71$ μV), $t(12) = 4.03$, $p = .002$. The ERPs to animal foils did not show a consistent decline from frontal to posterior sites, however. Within animal foils, there was a significant difference between Fz and Cz ($M = 1.24$ μV), $t(12) = 4.02$, $p = .002$, but not between Fz and Pz ($M = 1.86$ μV). This was different from the pattern observed at midline sites in young adults during this latency window (see ANOVA Table, Appendix A-20). Age group interacted with site at midline sites, $F(2,48) = 25.89$, $p < .001$, $\eta^2 = .52$, clearly indicating the hyperfrontality in the ERPs of older adults. Older adults produced a significantly more positive amplitude shift during this latency window frontally (Fz $M = 3.10$ μV) than did young adults ($M = 0.15$ μV), $t(24) = 2.84$, $p = .01$ (two tailed). The t-tests comparing neural responses as sites Cz (means: older = 0.78 μV; younger = 0.65 μV) and Pz (means: older = 1.29 μV; younger = 3.07 μV) were not significant.

There was also a significant three-way interaction between age group, word category, and site, $F(2,48) = 3.83$, $p = .03$, $\eta^2 = .14$. As illustrated in Figure 15, across all midline sites, young adults produced a more positive amplitude shift to emotional versus animal foils, whereas the reverse occurred for older adults. These differences were significant at site Pz, as older adults produced a more positive neural response to animal ($M = 1.86$ μV) as opposed to emotional ($M = 0.71$ μV) foils, $t(12) = -2.29$, $p = .04$ (two tailed), whereas young adults produced the most positive amplitude shift to emotional ($M = 4.20$ μV) rather than animal ($M = 1.95$ μV) foils, $t(12) = 2.09$, $p = .03$ (one tailed).

Component 3 (650 – 1050 ms)

Mean amplitude was obtained for each word category at all 17 sites during this latency window (see Appendix B-9). It is in this latency window that the effect of previous occurrence is typically noted as an enhanced ERP positivity for previously studied versus new words. However, in this experiment the impact of previous occurrence is confounded by the influence of emotionality and animal category for a proportion of the studied words as well as by the "targetness" studied words. With this in mind, repeated-measures ANOVAs were conducted on component 3 amplitude, with word category (studied word, emotional foil, animal foil and neutral foil), site (for midline sites), lateral plane and sagittal plane (for lateral sites) as the within-subject factors. Between-group analyses were also conducted, and will be reported in line with the within-subject results.

Analysis at lateral sites (F3, F4, P3, P4), revealed a main effect of word category on component 3 amplitude, F (2.07, 24.78) = 4.04, p = .03, η^2 = .25. Bonferroni corrected post-hoc comparisons indicated that the response to animal foils (M = 2.72 μV) was significantly more positive than that to studied words (M = 0.18 μV). There was a trend for greater positivity in frontal (M = 2.26 μV) versus parietal (M = 0.95 μV) sagittal regions, F (1,12) = 4.32, p = .06, η^2= .27 (see ANOVA Table Appendix A-21). These findings differed from what was observed for young adults during this latency window. Between-group analyses of component 3 amplitude at lateral sites revealed two interactions with age group, which remained significant after testing with scaled data (see ANOVA Table, Appendix A-22). There was an age group by word category interaction, F (3, 72) = 15.12, p <.001, η^2 = .39. Older adults produced the most positive amplitude shift to animal foils (M = 2.72 μV) compared to studied words (M = 0.18 μV) and other foils (emotional M = 1.38 μV; neutral m = 2.15 μV) whereas young adults produced the largest positivity to previously studied words (M = 5.23 μV) in comparison to all types of foils (emotional M = 0.92 μV; animal M = 0.77 μV; neutral M = 0.84 μV) during this latency window. There was also an interaction between age group and sagittal plane, $F(1,24) = 14.90$, $p = .001$, $\eta^2 = .38$, which once again reveals the expected hyperfrontality of older adults (frontal M = 2.26 μV; parietal M = 0.95 μV) in contrast to the posterior positivity seen in neural activity of younger adults (frontal M = 0.94 μV; parietal M = 2.94 μV).

Similar effects were observed at midline sites. However, within the older group, the trend for hyperfrontality observed at lateral sites reached significance in the analysis at midline sites (see ANOVA Table, Appendix A-23). There was a main effect of word category, $F(3,36) = 6.31$, $p = .001$, $\eta^2 = .36$. As seen at lateral sites, greater positivity was observed for animal foils (M = 2.80 μV) than studied words (M = -0.35 μV) at midline sites. There was also a main effect of site, $F(1.37,74.53) = 6.65$, $p = .01$, $\eta^2 = .36$, indicative of the hyperfrontality observed in the ERPs of older adults. Bonferroni corrected post-hoc comparisons revealed a significant difference between the positivity elicited at Fz (M = 2.62 μV) and at Pz (M = 0.71 μV). These effects are visualized in the ERP waveforms across midline sites as seen in Figure 13.

Increased positivity would be expected in right frontal and left parietal regions during this latency window in the context of source monitoring and old-new discrimination. As was done in experiments 1 and 2, separate within-group comparisons restricted to frontal (see ANOVA Table Appendix A-24) and parietal sites (see ANOVA Table Appendix A-25) were conducted to test for these effects in the older adult sample. Hyperfrontality was noted in analyses of midline and lateral sites for older adults. However, in the analysis restricted to frontal sites, there was no evidence for a right frontal effect, F (1,12) = 0.20, ns. Positivity at the right frontal site (M = 2.34 μV) did not differ significantly from that at the left frontal site (M = 2.18 μV). This is similar to what was seen in the analysis restricted to frontal sites in young adults.

There was no evidence for a left parietal old/new effect in this sample of older adults. In the analysis restricted to parietal electrodes, mean activity in the left parietal region (M = 0.97 μV) did not differ from that in the right parietal region (M = 0.94 μV), F (1, 12) = 0.3, ns. A similar absence of the left parietal effect was noted in ERPs of young adults in an analysis restricted to parietal sites during the LPC. There was a main effect of word category, however, F (2.04, 24.51) = 6.21, p = .006, η^2 = .34. As noted in other analyses during this latency window, older adults exhibited significantly greater positivity to animal foils (M = 2.13 μV) than to studied words (M = -0.54 μV).

Component 4 (800 – 1400 ms)

During this late portion of the waveform, the ERP response to previously studied words declined whereas the response to foils, particularly animal foils, remained elevated over virtually all sites (see Figure 12). Thus, areas under the curve for this latency window were obtained for target words and animal foils (see Appendix B-10). A repeated-measures ANOVA was conducted on mean component 4 amplitude at lateral sites, with word category (target words vs. animal foil), lateral plane (left vs. right) and sagittal plane (frontal vs. posterior) entered as the within-subject factors (see ANOVA Table, Appendix A-26). There was a main effect of word category at lateral sites, as animal foils (M = 2.03 μV) generated significantly more positivity in this latency window than did target words (M = -0.35 μV), F (1,12) = 16.85, p = .002, η^2 = .58. There were no other main effects or interactions during this latency window for older adults.

During this latency window, different distinctions between word conditions were observed for younger and older adults (see Figures 8 and 14). For young adults, the early positivity to emotional foils was maintained during this late region of the waveform whereas the large positive response to target items declined into a late negativity. A similar late negativity to target items is also seen in responses of older adults, although not as large a deflection as for young adults. However, for older adults, it is the early positivity to animal foils that is relatively maintained in this late latency window. As such, age groups were compared in two mixed-design, repeated-measures ANOVAs on component 4 amplitude. At midline sites, word category (targets, emotional foils, and animal foils) and site (for midline sites) were entered as the within-subject factors and at lateral sites, word category, lateral (left vs. right) and sagittal (frontal vs. posterior) planes were entered as within-subject factors. There were no significant between-group differences, nor any interactions with age group at either midline or lateral sites during this latency window.

Temporal Sequence of Topographical Distributions

Profile comparisons were performed on waveform areas in successive 100 ms intervals from stimulus onset at 0 ms to 1600 ms following onset. Topographical maps were based on correct trials only. To provide additional information on the temporal course of scalp distributions of neural activity distinct to previous occurrence, emotionality, and to the category effect associated with "animalness", difference waveforms were derived by subtracting the ERPs to neutral foils from the ERPs to studied words (Figure 16), from those to emotional foils (Figure 17) and from those to animal foils (Figure 18). These topographical maps allowed for an inspection of the temporal course of target recognition processes, as well as a comparison of neural activity to previously seen words and emotional words versus the animal category effect in this sample of older adults.

Once the neural activity associated with general word evaluation was removed, the neural activity specific to previous occurrence in this sample of older adults was characterized by relatively more positive activity in the first 500 ms after word onset and followed by sustained negativity. Left frontal positivity was noted beginning by 100 ms after word onset. This was maintained until 400 ms, was combined with a right parietal positivity which began between 200 and 300 ms and was sustained until 700 ms following word onset. The area of most positivity was observed from 300 to 400 ms after word onset, earlier than expected based on the scalp topographies to previous occurrence in younger adults. A slight right frontal positivity was noted from 500 to 700 ms after word onset. The late negativity observed to previous occurrence in this sample of older adults clearly resembles the late negativity also observed for young adults.

Comparison of the scalp topographies elicited by emotionality (Figure 17) and the animal category (Figure 18) revealed consistent distinctions for these two categories of non-target words. The scalp topographies to emotionality are best characterized by an overall negativity across the scalp and over the entire recording epoch, with the exception of a small distinct region of right temporal positivity beginning between 200 and 300 ms and lasting until the end of the recording epoch. In contrast, the neural response to the category of animal words was associated with widespread positivity. Positivity to animal foils was relatively early, beginning between 100 and 200 ms. This positivity was primarily left-lateralized, shifting from posterior maxima in the first regions of the waveform to a left frontal maximal positivity from 800 to 1600 ms. At the same time, right-lateralized negativity was noted throughout much of the waveform, shifting from frontal and central regions earlier in the waveform to posterior regions during the later portions, from 1100 to 1600 ms. These responses are distinct from those observed for emotionality and animalness in young adults, which were characterized by general positivity to emotionality in contrast to negativity to animal foils.

Discussion

Overall, the results of experiment 3 concur with the findings of experiments 1 and 2. Once again, in the context of a memory task, something other than previous occurrence was shown to influence both mnemonic decisions and ERPs. Together, these three experiments provide strong converging evidence for the theory that the LPC may represent a response to stimulus salience in general, as opposed to recollection *per se*. Contrary to expectation, however, reactivity to emotional salience was not enhanced in this sample of older adults. The older adults were not influenced by emotionality either behaviourally, in terms of increased frequency of source errors for emotional compared to neutral foils, or in electrophysiological response.

Behavioural Data

Older adults made significantly more source errors for animal foils in comparison to both emotional and neutral foils, which did not differ. These findings suggest that older adults were more influenced by the semantic similarity (animalness) of a proportion of the target and foil words. This finding is consistent with the false familiarity effects produced by manipulating the conceptual fluency of target words (Whittlesea, 1993). The fact that older adults did not appear to notice a categorical similarity between the same proportion of emotional targets and foils further supports the hypothesis that the effects of emotion is distinct from a categorical effect alone.

ERP Data

The responsivity to the categorical effect associated with animalness noted in behavioural responses was also evident in the electrophysiological responses, as the ERP waveform to animal foils is the most prominent waveform across all sites over the entire recording epoch. Although older adults recognized previously studied words as well as did young adults at test, they did not produce the typical late positivity to target words. Instead, older adults showed a brief positivity to studied words, which then declined into a sustained late negativity. Contrary to expectation, older adults did not display heightened automatic reactivity to the emotional salience engendered by negatively valenced words. At the outset of this series of experiments, it was expected that older adults would be more likely than younger adults to react to non-target, yet salient, emotional information. Instead, the opposite was observed. These distinctions between young and older adults observed for behavioural and ERP responses to the same stimuli, suggest that stimulus salience is determined to a great degree by the attentional capacity and goals of the individuals performing the task, as well as the context in which the stimuli are encountered.

The age differences noted in types of source errors may be interpreted according to the theory that feelings of familiarity are attributions of current processing fluency to some source that seems likely (Jacoby et al., 1989a). Older adults tended to utilize semantic strategies for encoding words at study, whereas young adults reported that they just looked at the words and hoped they would remember them. Thus, older adults were more likely to have formed a categorical distinction based on "animalness" at study, making "animalness" goal-relevant. This strategy would then lead to increased frequency of errors to semantically similar animal foils. For example, one man commented that he remembered seeing a rodent on the study list and then when he saw more than one rodent on the test list he was not sure which one he had seen before. When asked with probing questions during debriefing, most young adults commented that they noticed animal words at test, but they were less likely to see these foils as goal-relevant. Instead, young adults readily determined that animal foils were similar to studied words but were not, in fact, previously seen. Thus, it appears that for young adults, the fluent processing of animal foils at test was readily recognized as being due to semantic similarity to a proportion of study words, and was attributed correctly to the present condition. However, older adults may not have had the attentional capacity required to make such an analytical judgement under the time constraints of the test. As such, the fluent processing based on the semantic similarity of animal foils was misattributed according to task goals, and hence attributed to previous occurrence.

It has been proposed that deficits underlying a decline in source monitoring may occur at various levels of processing involved in memory formation and retrieval. At the level of processing the initial encounter of the stimulus, it has been proposed that source errors occur because details go unnoticed or fail to be retained for further processing (Hashtroudi et al, 1989; Shimamura & Squire, 1987). Johnson and Chalfonte (1994) propose that self initiated reactivation of encoded information serves to strengthen and bind together aspects of memory, and that deficits at this stage result in source monitoring errors. Further, deficits in evaluative processes at the stage of memory retrieval may also be related to source errors (Johnson et al., 1993). In line with this final theory, previous research with ERPs has shown that differences in attentional resources affect the ability to selectively respond to task-relevant information during complex source discrimination tasks (e.g., Dywan et al., 1994, 1998). In the context of a running recognition task, older adults and distracted young adults exhibited an increased ERP late positive response and increased frequency of source errors for familiar yet non-target information, in comparison to young adults working under full attentional capacity. These ERP data strongly suggest that source monitoring deficits are related to attentional resources. Attentional capacity is central to the ability to monitor the relative salience of information and the ability to inhibit response to salient yet task-irrelevant information. Thus, in the present sample of older adults, a decline in attentional capacity could have been related to a decline in controlled source evaluation processes at test, thus making stimulus attribution according to task goals the most likely response even when it was wrong.

General Discussion

The goal of this series of experiments was to explore the possibility that manipulating the emotional salience of information could lead to false feelings of familiarity within a recognition memory context. It was anticipated that participants would experience an automatic reactivity, or change in feeling state, to negatively valenced emotional words. In the context of a source monitoring paradigm, this reactivity would be misinterpreted as a feeling of familiarity which would be expressed in terms of increased frequency of source errors, as well as in increased LPC amplitude, to emotionally salient non-target words. In addition to replicating the well-established pattern of ERP reactivity to recollected items, the predicted effects of emotionality were found in the first two experiments.

Previously studied words were most likely to be recognized at test, and they were associated with most positive LPC amplitude, thus replicating a large body of ERP and memory literature (e.g., Donaldson & Rugg, 1998; Dywan et al., 1998; Johnson et al., 1998; Rugg et al., 1997; Smith, 1993; Tendolkar & Rugg, 1998; Wilding & Rugg, 1997). There was some evidence for a right-lateralized frontal positivity for previously studied words, thought to reflect stimulus evaluation processes required for source decisions (Johnson, 1993; Johnson et al., 1997a). However, in contrast to a large body of literature, there was no indication of the anticipated left parietal old/new effect (e.g., Donaldson & Rugg, 1998; Mark & Rugg, 1998; Rugg, Schloerscheidt & Mark, 1998; Schloerscheidt & Rugg, 1997; Tendolkar & Rugg, 1998; Wilding & Rugg, 1997). These findings are similar to those observed by Johnson et al. (1997b) and suggest that the left parietal effect may not be reliable.

In addition, the present results demonstrate that in the context of remembering, relatively automatic reactivity to something other than familiarity can lead to false memory attributions. Behaviourally, in comparison to other categories of new words, non-target emotional words were more likely to be falsely "remembered" at test. Electrophysiologically, emotionality elicited a generally distributed positivity that began very early and was maintained over the entire recording epoch, possibly indicating sustained processing of emotionally salient information (Erhan et al., 1998). In contrast, the ERPs to recollected items were positive during the LPC and declined dramatically into a late negativity, the functional significance of which is not known (Wilding & Rugg, 1997). The categorical effect associated with animal words was characterized by negativity throughout the entire waveform, with a posterior positivity occurring very briefly during the LPC. The findings suggest that emotionality is a potent source of salience, having an impact on behavioural and electrophysiological response that is distinct from the effects of previous occurrence and also distinct from the impact of a categorical effect alone.

Emotional salience elicited neural arousal very early in processing, within the first 100 ms following word onset for young adults. Although unanticipated, these early ERP effects suggest that emotional stimuli may be the focus of early attentional selection, possibly leading to enhanced processing of emotional words (Luck & Girelli, 1998). According to the "early-selection" model of conscious control proposed by Jacoby, Kelley and McElree (in press), conscious memory retrieval begins very early in processing, and may take longer to complete than automatic processes. According to this model, automatic and controlled processes may operate in parallel, each serving as independent bases for responding.

It may be that negatively valenced, emotionally salient stimuli are particularly likely to capture attention automatically, in a way that neutral information does not. According to Robinson's (1998) model of the preattentive mechanisms involved in emotional response, the processes involved in perceiving and determining emotional valence are automatic. The automatic processing elicited by emotional stimuli normally triggers controlled processing that would lead to the production of an emotion. However, it appears that in the context of controlled recollection, emotional reactivity may be interpreted in line with processes involved in judging previous occurrence. This could account for the increased frequency of false memories for emotionally salient new words found for young adults.

There was no ERP evidence to suggest early attentional arousal to emotionality, or to other categories of stimuli, in the older adult group. This may be some indication that attentional mechanisms involved in early selection processes may be vulnerable to decline in aging. Such a loss would make complex tasks involving selective attention very difficult for older adults.

In contrast to previous work involving manipulations of item familiarity (e.g., Dywan et al., 1998; Jacoby et al., 1989b), a reduction in attentional capacity by distraction was not needed to observe altered memory attributions and ERP response to emotional information in experiments 1 and 2. It was anticipated, therefore, that a reduction in attentional capacity due to aging would be associated with more pronounced response to emotionally salient non-target information in the source memory context. This was not observed, however. On the contrary, older adults failed to exhibit evidence of reactivity to emotionally salient information, either behaviourally or electrophysiologically. Instead, older adults exhibited increased frequency of source errors and late positive ERP response to non-emotional non-target words that were semantically related to a proportion of target words, the category animal words. In fact, although older adults were able to recognize previously studied words at test as well as young adults, older adults produced very little positivity to previously studied words or emotional foils. Instead, the greatest positivity was noted in response to animal foils throughout the recording epoch. The reason for this is not known. It may be that older adults were more likely to have employed a semantic strategy at encoding and so were more likely to interpret semantically related words as goal-relevant at test. This interpretation is consistent with previous findings that manipulation of *conceptual fluency* can have a greater impact on false feelings of familiarity than *perceptual fluency* (Whittlesea, 1993). Despite the unexpected outcome, the results of the older adults provide converging evidence that reactivity to something other than previous occurrence can lead to false memory attributions and increased ERP response in the context of a memory paradigm.

It was hypothesized that depressed mood would influence memory attributions, particularly to emotionally salient non-target information. Participants in all three experiments exhibited, on average, a very mild level of depression (if any). Although some correlation between depression and source monitoring performance measures were observed in all three experiments, these were not consistent, indicating that although depression may have some impact on memory attributions such effects may not be reliable in a non-clinical population.

The results of this series of experiments provide evidence to confirm previous speculation (e.g., Jacoby et al., 1989; Whittlesea, 1993) that mnemonic decisions are to some degree based on the differential salience of items. That is, when individuals make false positive responses within the context of a memory paradigm, it may not be as a consequence of a lowered response criterion, as has been traditionally assumed (for a review see Schacter, Norman & Koutstaal, 1998). Rather, false memory attributions may be due to the fact that some items elicit enhanced neural reactivity and that this reactivity is misinterpreted in line with the task goals.

These data have important implications for two separate issues in the memory literature. The first concerns the occurrence of false memories in the context of recollection, an issue that has importance in considering the validity of eyewitness testimony (e.g., Loftus, 1979) and in the use of hypnosis in "recovering" lost memories (see Schacter, 1995 for a review). The results of the first two experiments indicate that emotionally charged information is likely to elicit a neural response, and that this response may be misattributed to familiarity if it occurs while an individual is actively attempting to recollect some previous occurrence. The implications for emotionally based responding in such a context are obvious, and need to be taken into consideration by those involved in attempts to encourage the recollection of "forgotten" events.

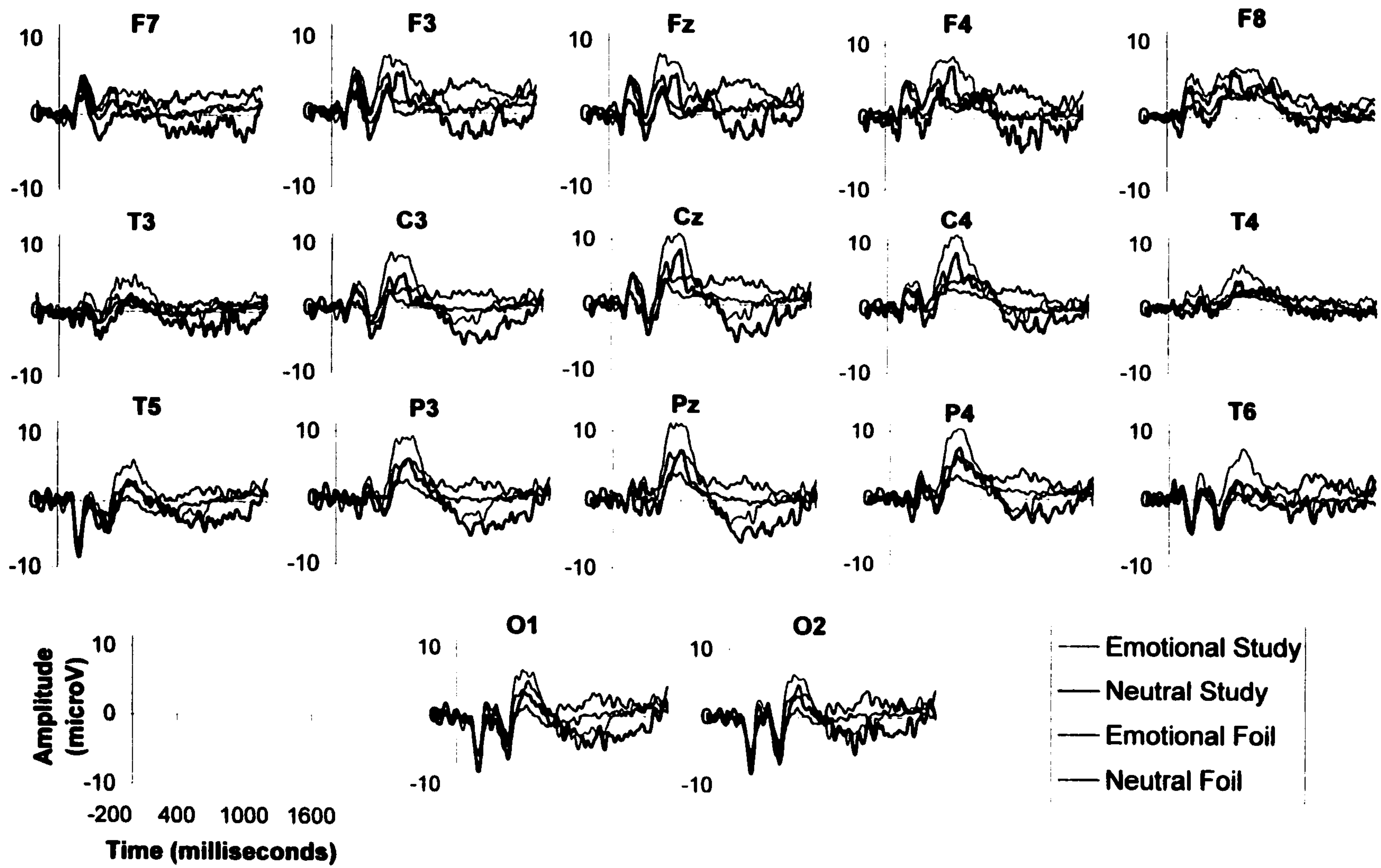
The second issue involves the interpretation of the LPC in defining the neurophysiological underpinnings of mnemonic functions. It is commonly argued that the LPC is an index of recollection (e.g., Allan & Rugg, 1998; Mark & Rugg, 1998;

Smith. 1993). This interpretation would also be supported in the present series of studies if one only considered the ERP distinctions between previously studied and new words. However. in the first experiment, the emotionality of half of the studied words was a potent factor in eliciting higher amplitude LPC in comparison to neutral studied words. Moreover. the LPC amplitude to non-studied emotional foil words exceeded that of neutral studied words at posterior sites. One might assume that the heightened amplitude of the LPC occurred as a result of emotional foils being mistaken for studied words. However. this could not have been the case. as ERPs were averaged based on correct trials only. Therefore, it appears that the high amplitude LPC to emotional foils influenced mnemonic decisions but was not a consequence of those decisions. Similar effects of emotional salience on mnemonic decisions were observed in experiment 2. although the timing of the ERP effects was somewhat earlier. Concurrent effects were also observed in experiment 3. although for a non-emotional category of new words.

Although other sources of stimulus salience were shown to have a similar impact to previous occurrence on LPC amplitude. reactivity to non-recollected information did not follow the same pattern of distribution over time. Previous occurrence was associated with a time-limited positivity during the latency window corresponding to the LPC, followed by a topographically diffuse and temporally sustained late negativity. In contrast. emotionality elicited a topographically diffuse and sustained positivity. A similar pattern of sustained positivity to animal words was observed for older adults.

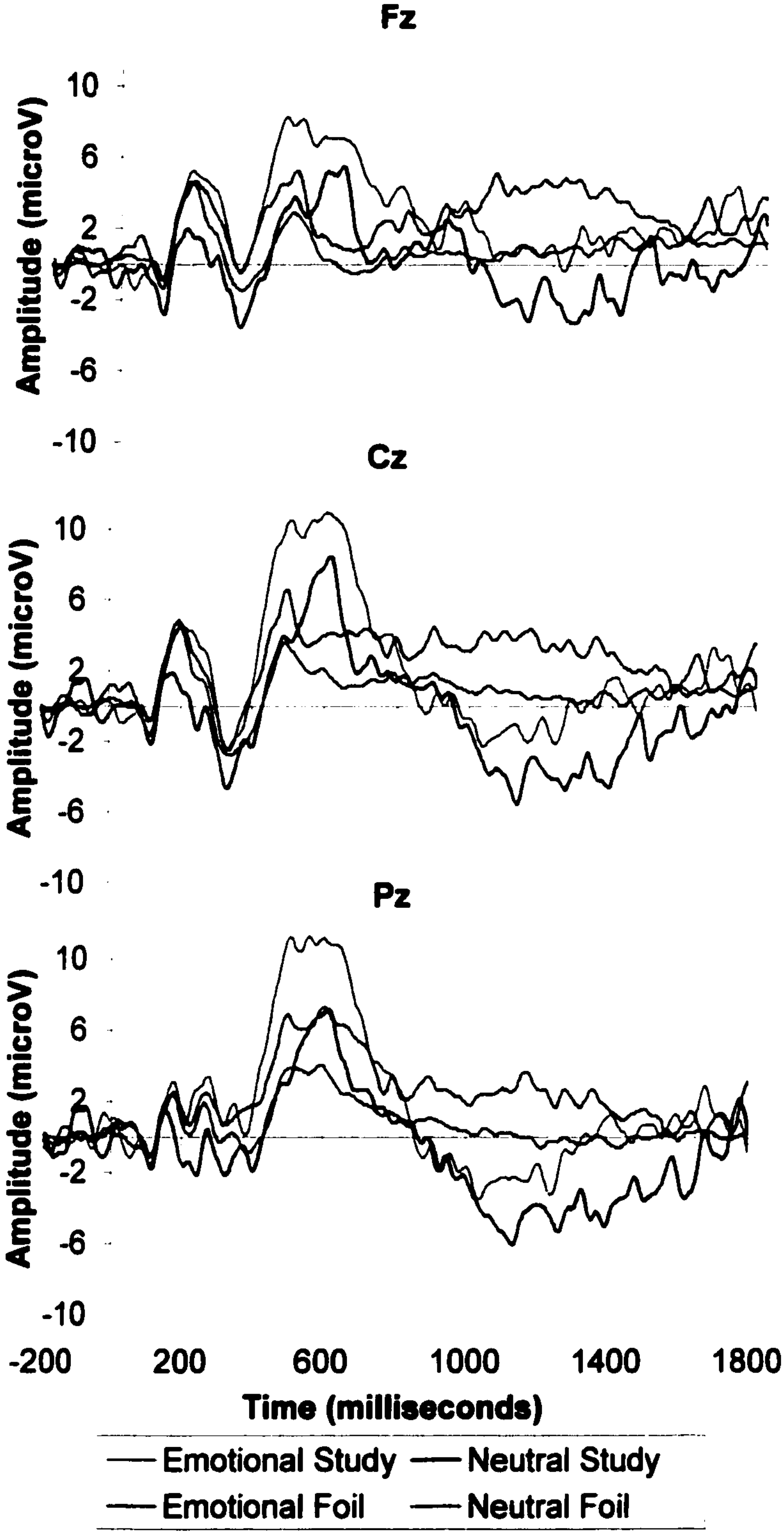
The results of these three experiments provide strong evidence that the LPC is not in itself an index of memory processes in the brain. Rather, the LPC appears to be a nonspecific index of stimulus salience. What determines relative stimulus salience, or which stimuli receive enhanced attentional allocation, appears to depend on the goals of the individual as well as the context in which the items are encountered. For young adults, when encountered during remembering, emotional information just *feels* familiar.

Figure 1. Distribution of ERP Waveforms Across the Scalp in Experiment 1.



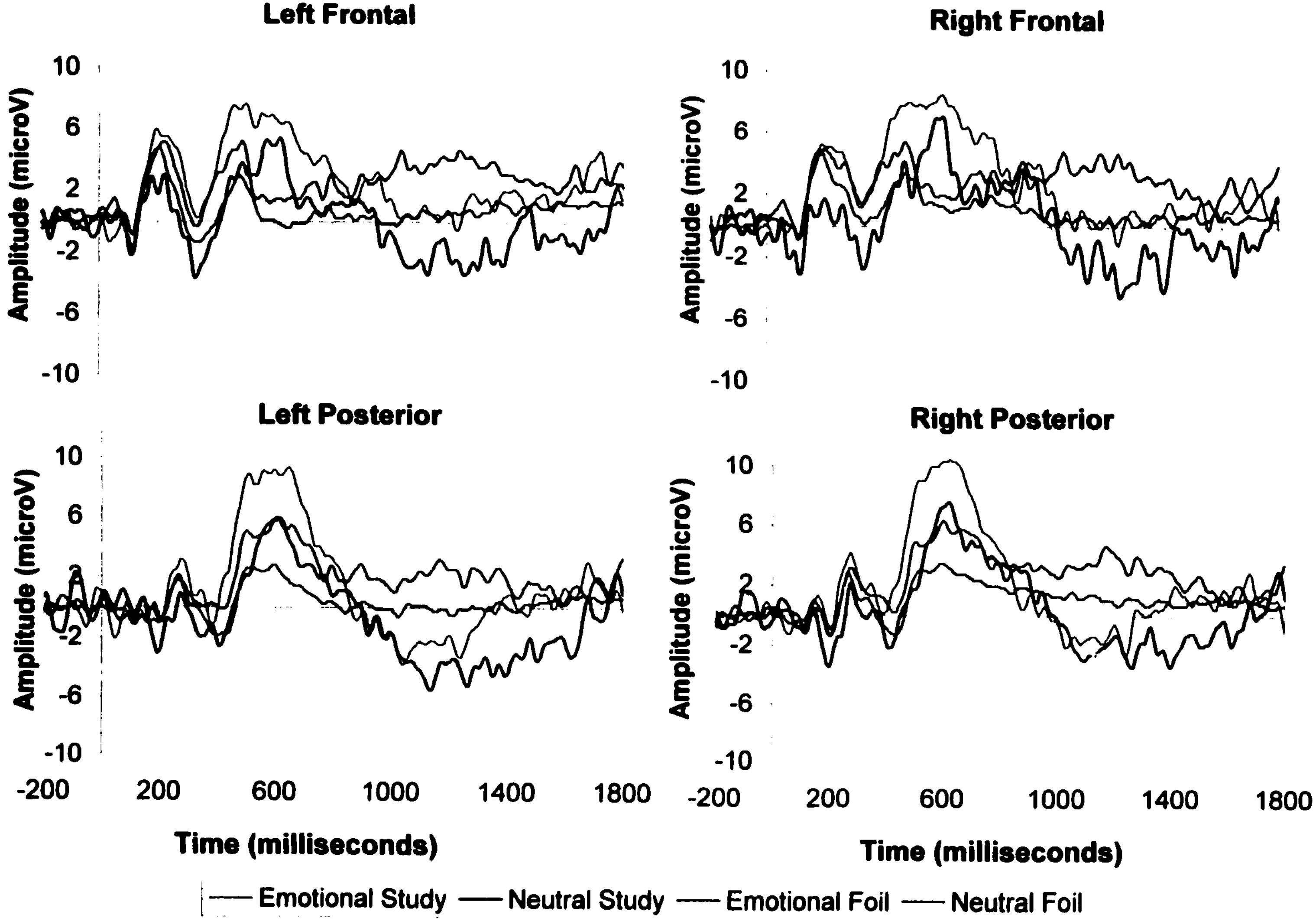
Note: Referenced to balanced ears.

Figure 2. Distribution of ERP Waveforms Across Midline Sites in Experiment 1.



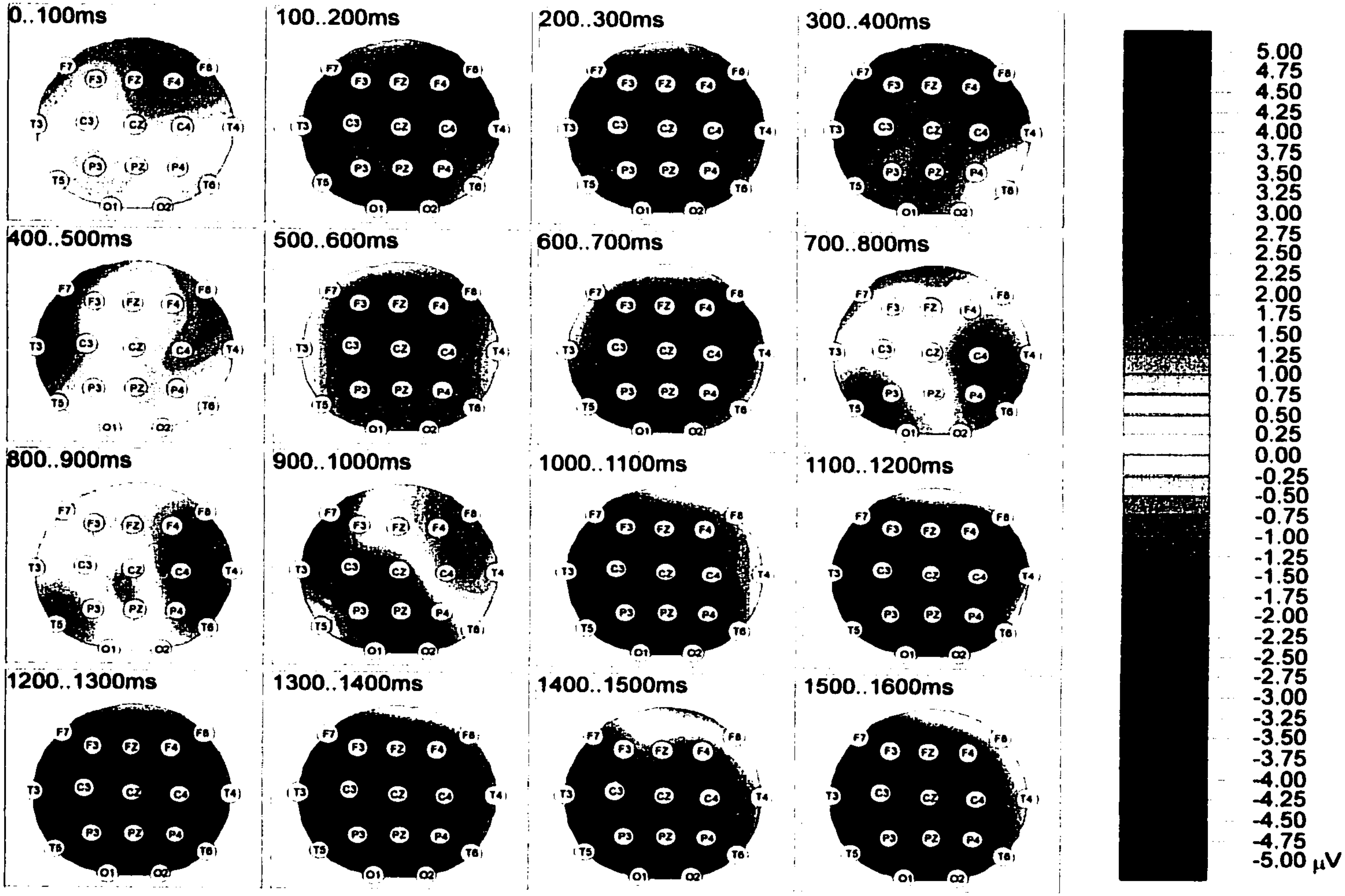
Note: Referenced to balanced ears.

Figure 3. Distribution of ERP Waveforms Across Lateral Sites in Experiment 1.



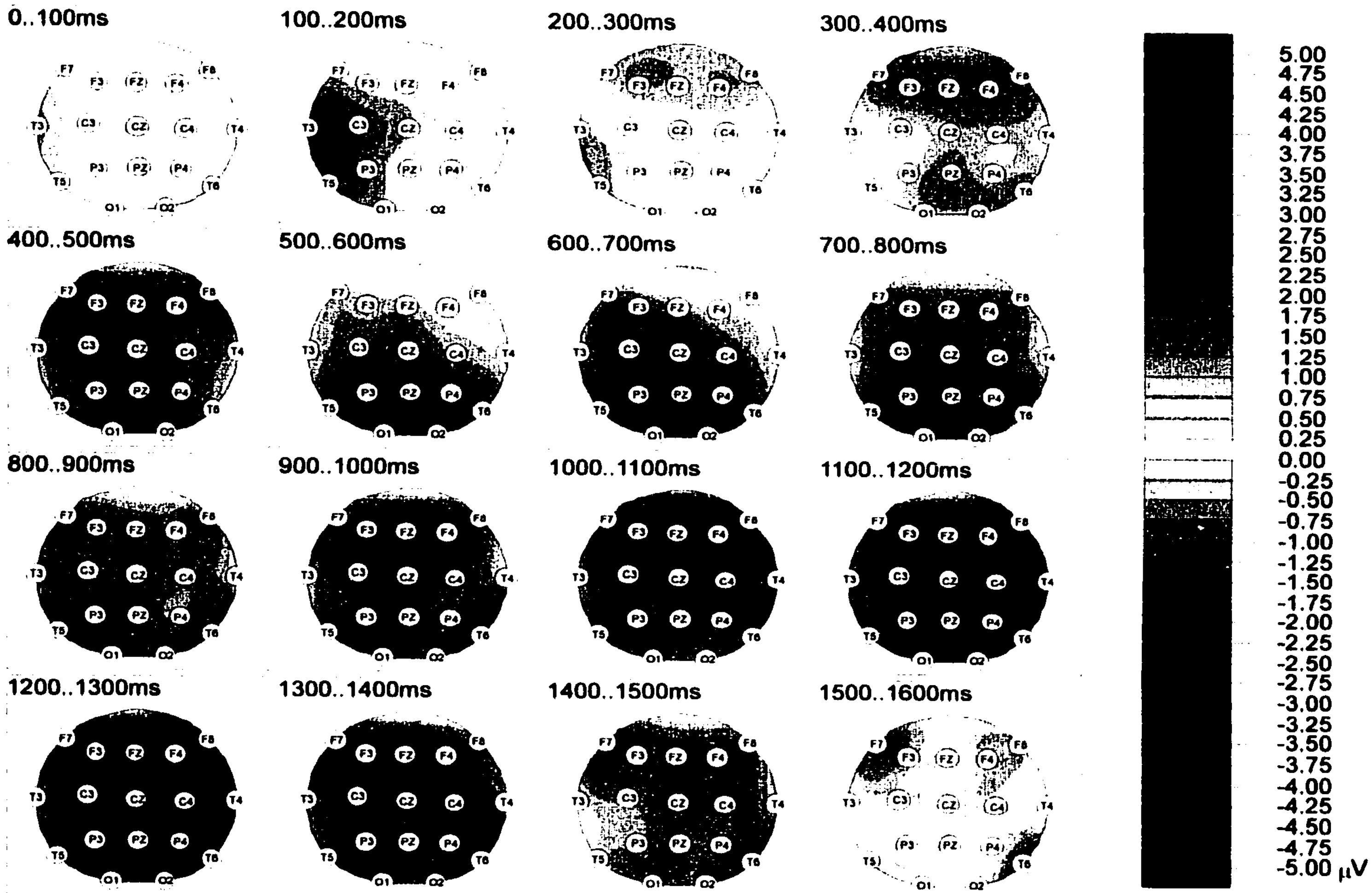
Note: Referenced to balanced ears.

Figure 4. Temporal Sequence of Topographical Distribution of ERPs Elicited by Previous Occurrence in Experiment 1.



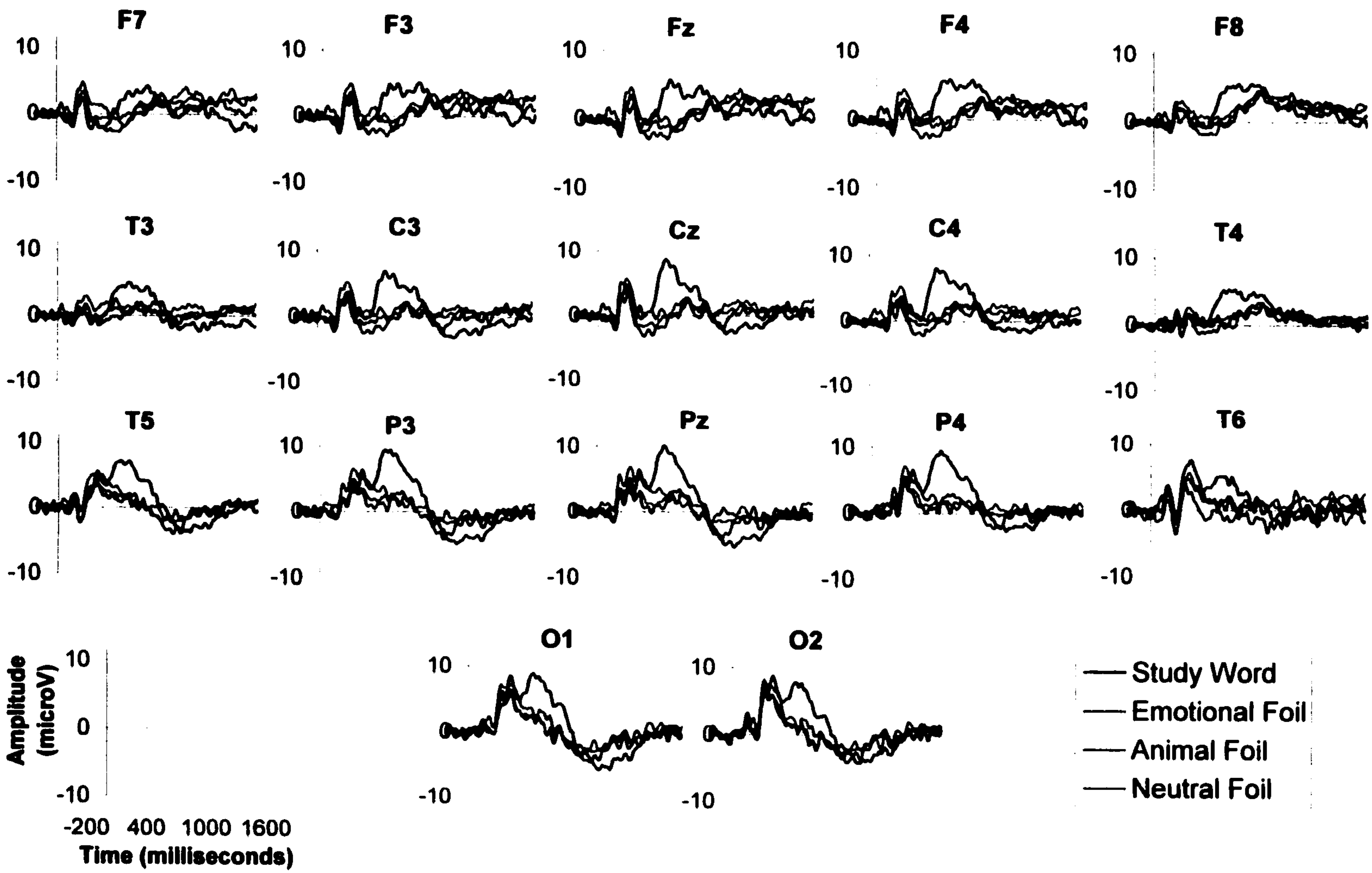
Note: Positive voltages are indicated in red and negative voltages are indicated in blue for ERP activity in successive 100 ms intervals from stimulus onset at 0 ms to 1600 ms. Scalp topographies are shown for difference waveforms derived by subtracting ERPs to neutral foils from ERPs to previously studied words, referenced to balanced ears. Orientation: Fz = front, Pz = back, T3 = left, T4 = right.

Figure 5. Temporal Sequence of Topographical Distribution of ERPs Elicited by Emotionality in Experiment 1.



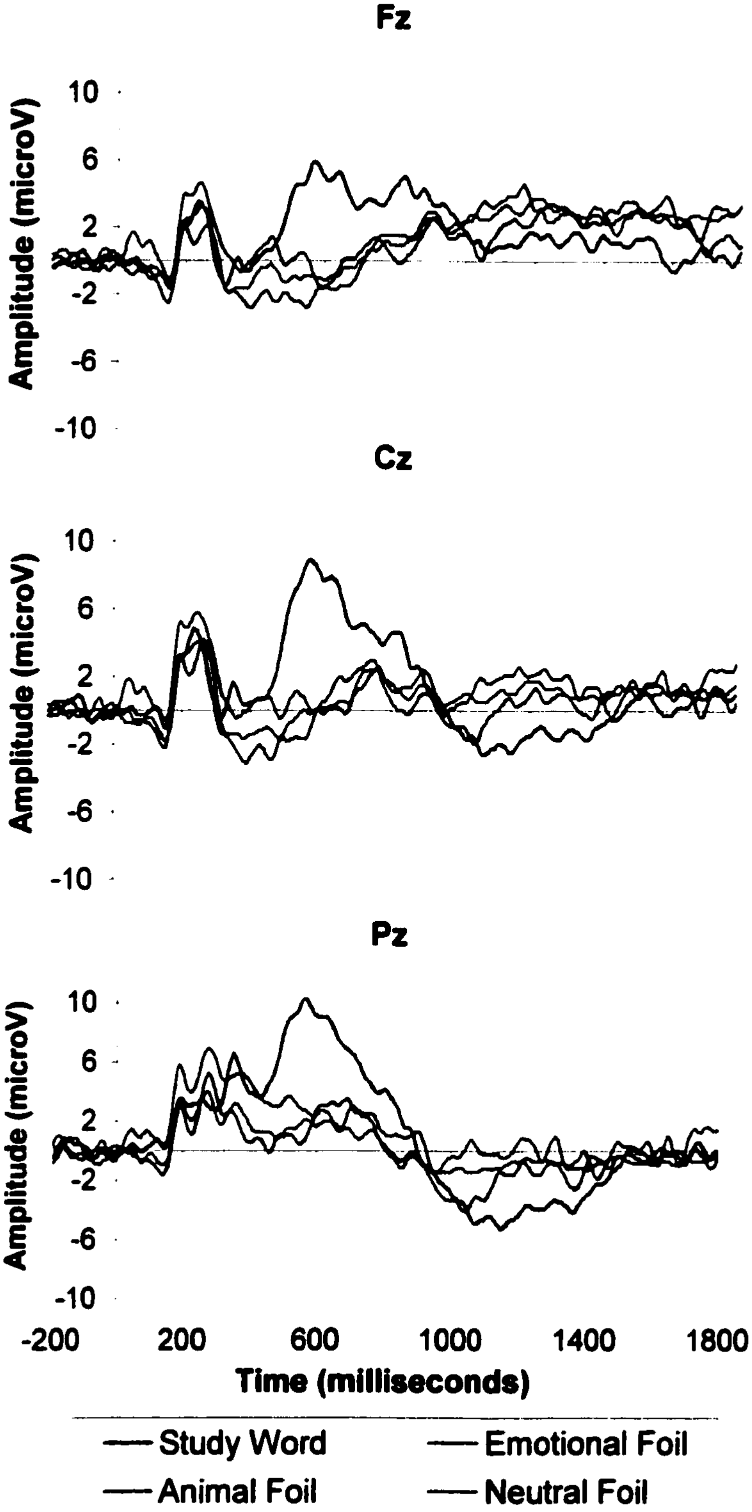
Note: Positive voltages are indicated in red and negative voltages are indicated in blue for ERP activity in successive 100 ms intervals from stimulus onset at 0 ms to 1600 ms. Scalp topographies are shown for difference waveforms derived by subtracting ERPs to neutral foils from ERPs to emotional foils, referenced to balanced ears. Orientation: Fz = front, Pz = back, T3 = left, T4 = right.

Figure 6. Distribution of ERP Waveforms Across the Scalp in Experiment 2.



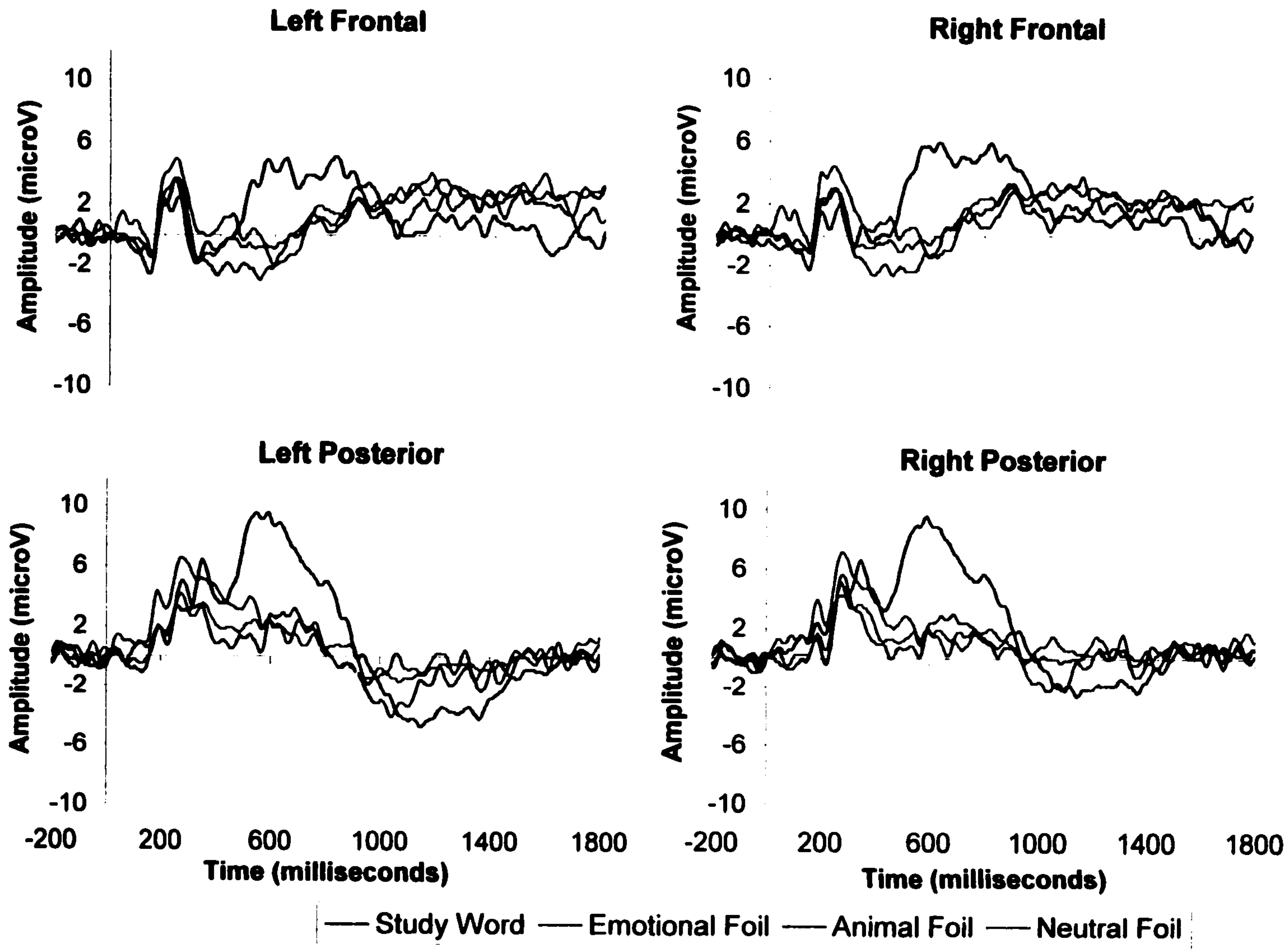
Note: Referenced to balanced ears.

Figure 7. Distribution of ERP Waveforms Across Midline Sites in Experiment 2.



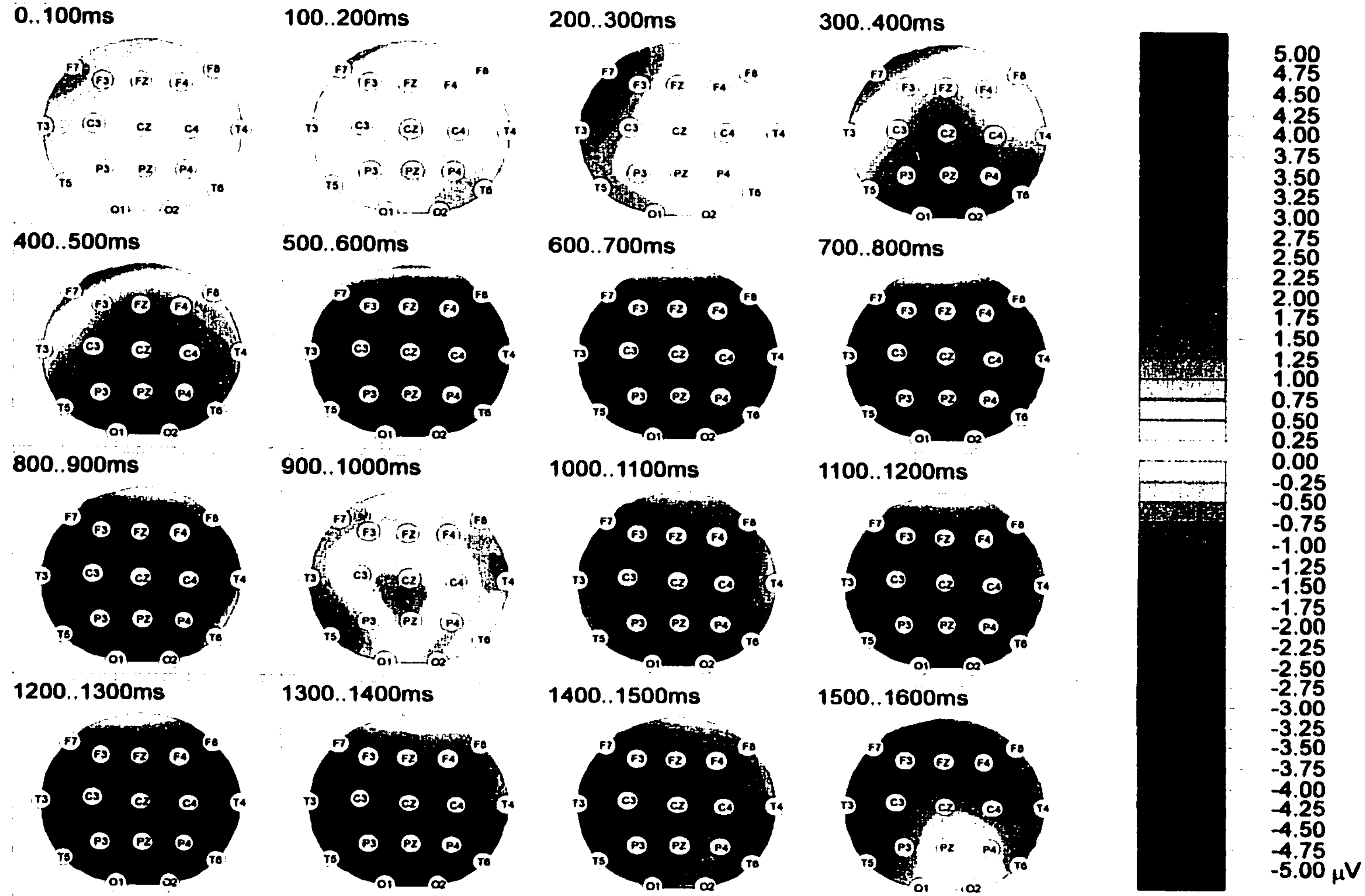
Note: Referenced to balanced ears.

Figure 8. Distribution of ERP Waveforms Across Lateral Sites in Experiment 2.



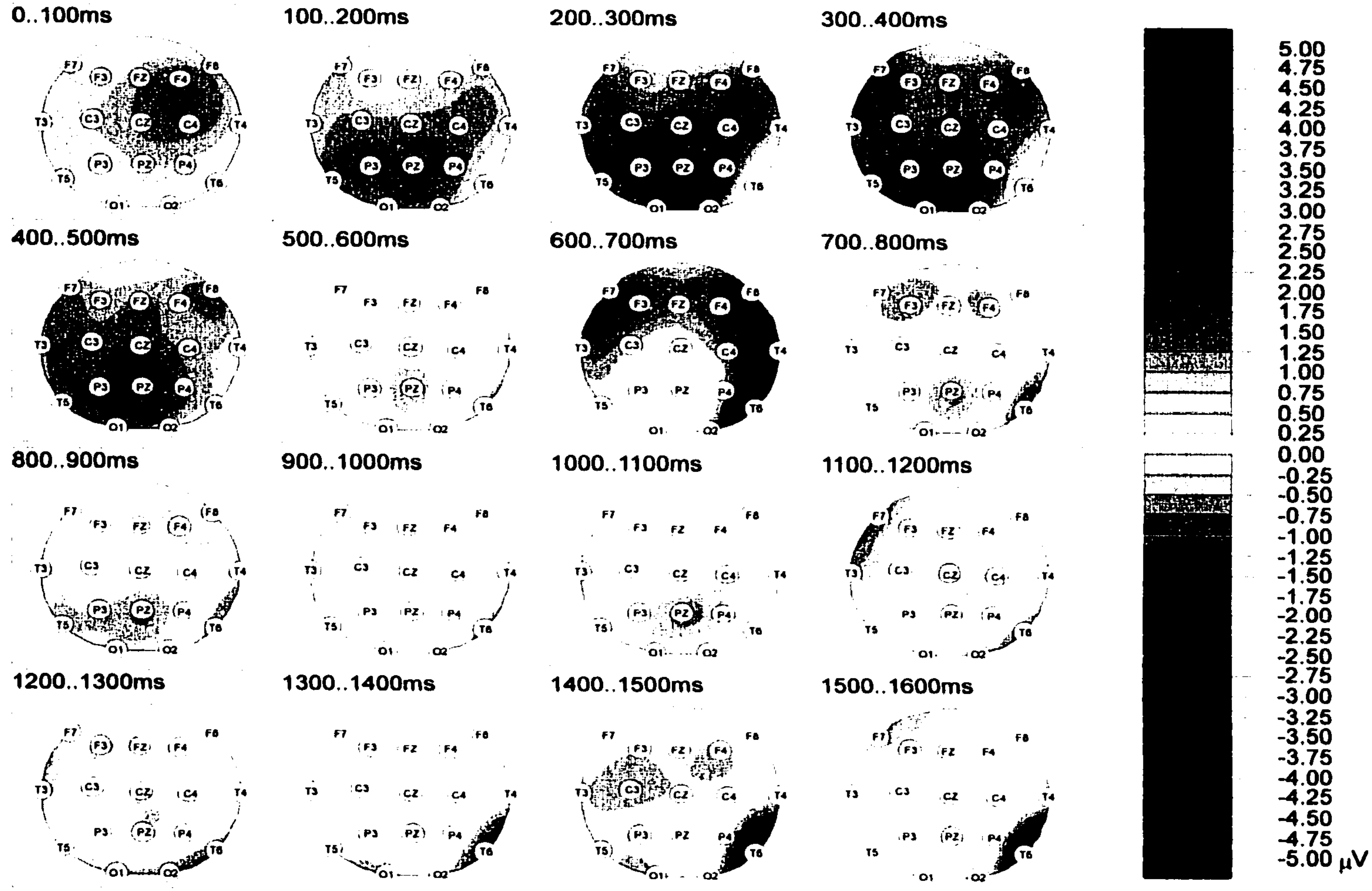
Note: Referenced to balanced ears.

Figure 9. Temporal Sequence of Topographical Distribution of ERPs Elicited by Previous Occurrence in Experiment 2.



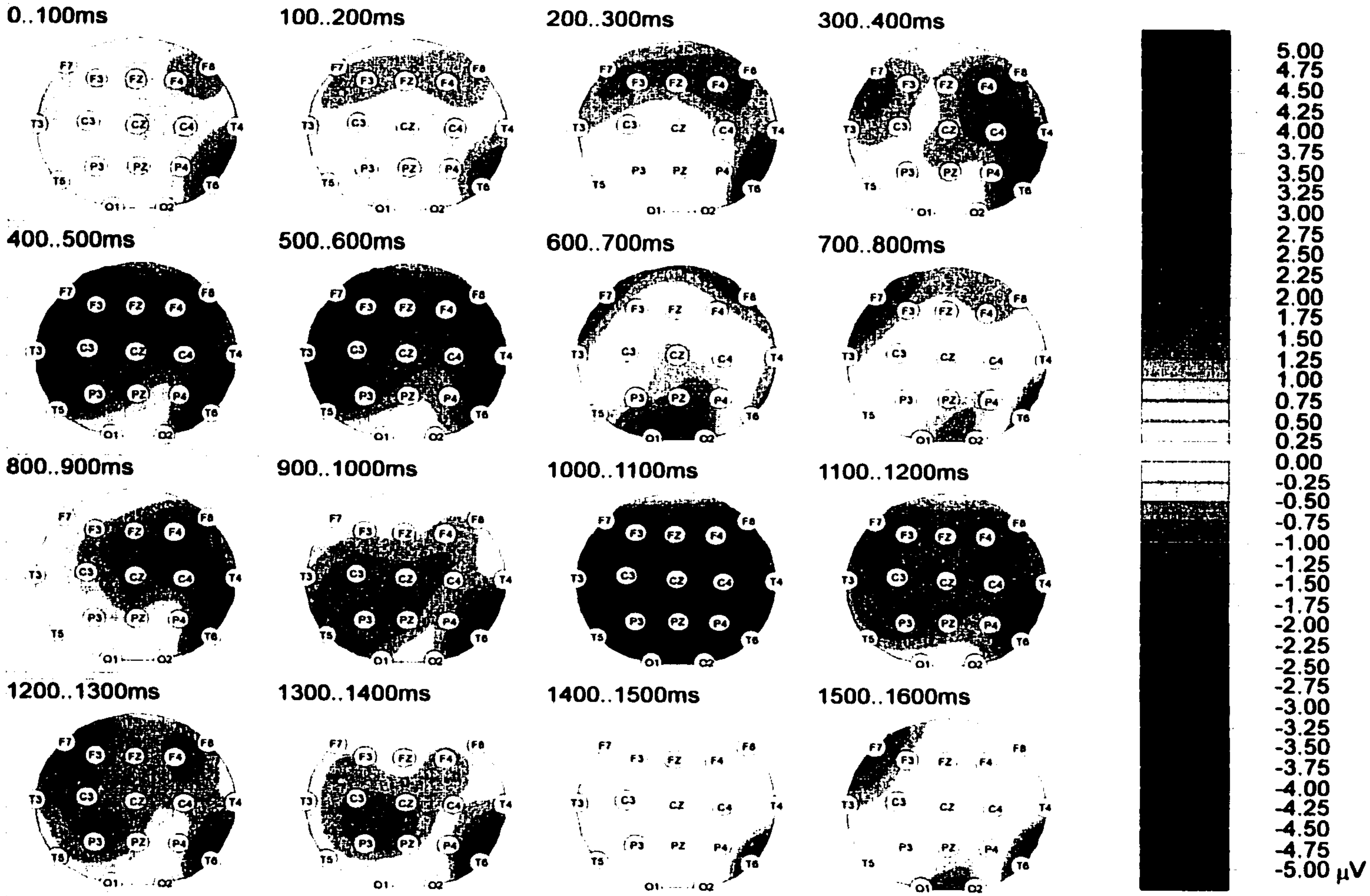
Note: Positive voltages are indicated in red and negative voltages are indicated in blue for ERP activity in successive 100 ms intervals from stimulus onset at 0 ms to 1600 ms. Scalp topographies are shown for difference waveforms derived by subtracting ERPs to neutral foils from ERPs to previously studied words, referenced to balanced ears. Orientation: Fz = front, Pz = back, T3 = left, T4 = right.

Figure 10. Temporal Sequence of Topographical Distribution of ERPs Elicited by Emotionality in Experiment 2.



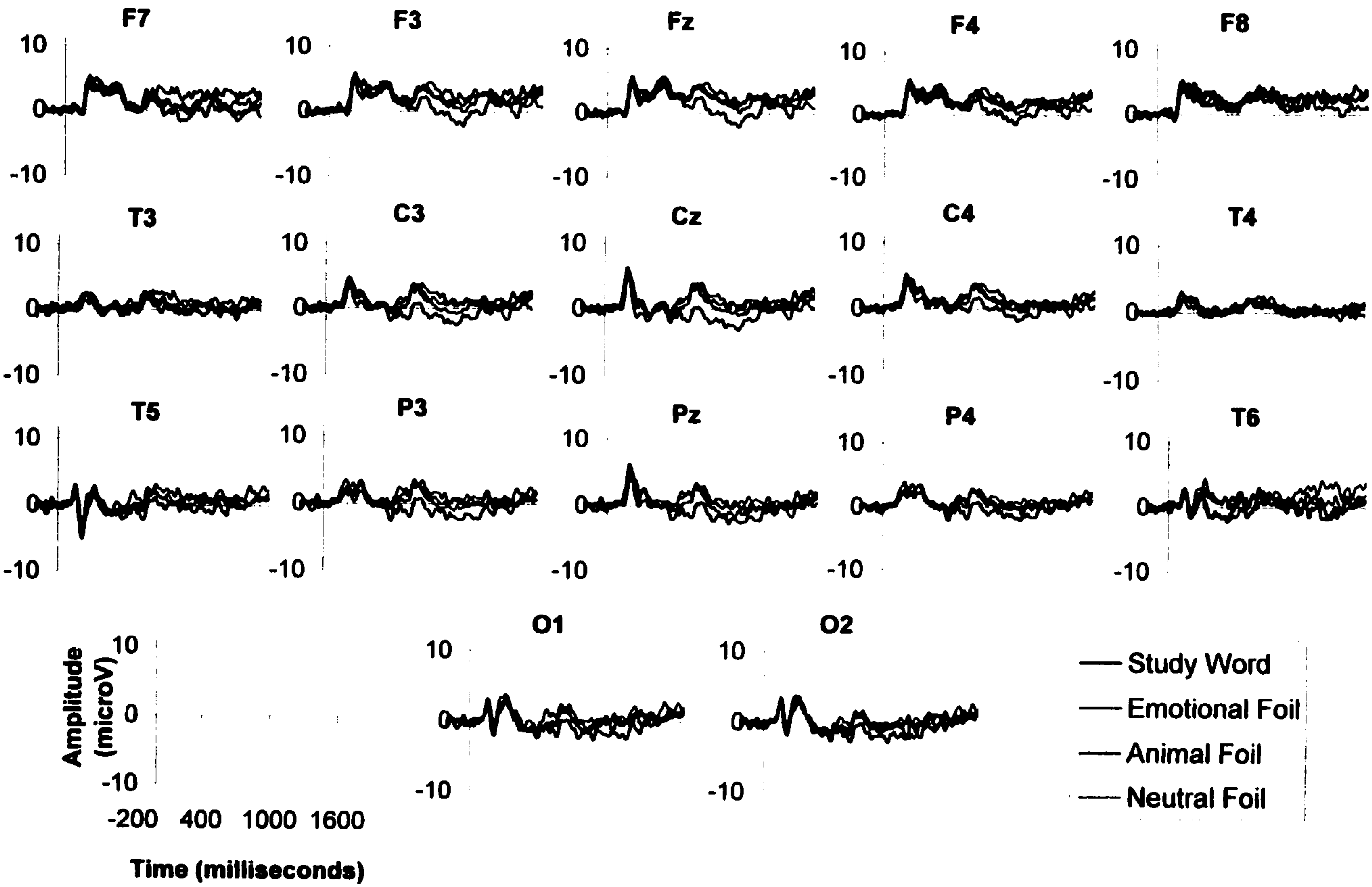
Note: Positive voltages are indicated in red and negative voltages are indicated in blue for ERP activity in successive 100 ms intervals from stimulus onset at 0 ms to 1600 ms. Scalp topographies are shown for difference waveforms derived by subtracting ERPs to neutral foils from ERPs to emotional foils, referenced to balanced ears. Orientation: Fz = front, Pz = back, T3 = left, T4 = right.

Figure 11. Temporal Sequence of Topographical Distribution of ERPs Elicited by the Animal Category in Experiment 2.



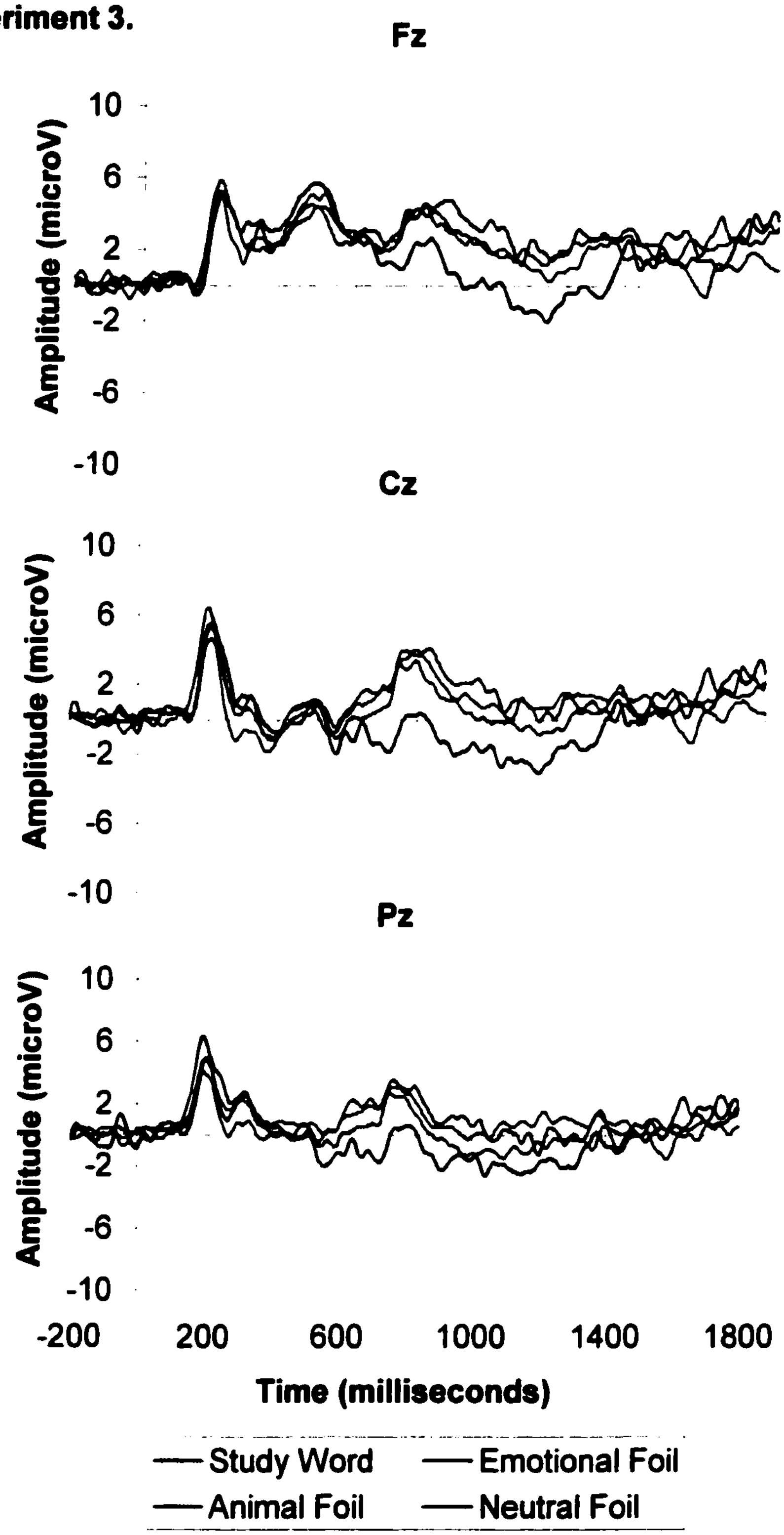
Note: Positive voltages are indicated in red and negative voltages are indicated in blue for ERP activity in successive 100 ms intervals from stimulus onset at 0 ms to 1600 ms. Scalp topographies are shown for difference waveforms derived by subtracting ERPs to neutral foils from ERPs to animal foils, referenced to balanced ears. Orientation: Fz = front, Pz = back, T3 = left, T4 = right.

Figure 12. Distribution of ERP Waveforms Across the Scalp in Experiment 3.



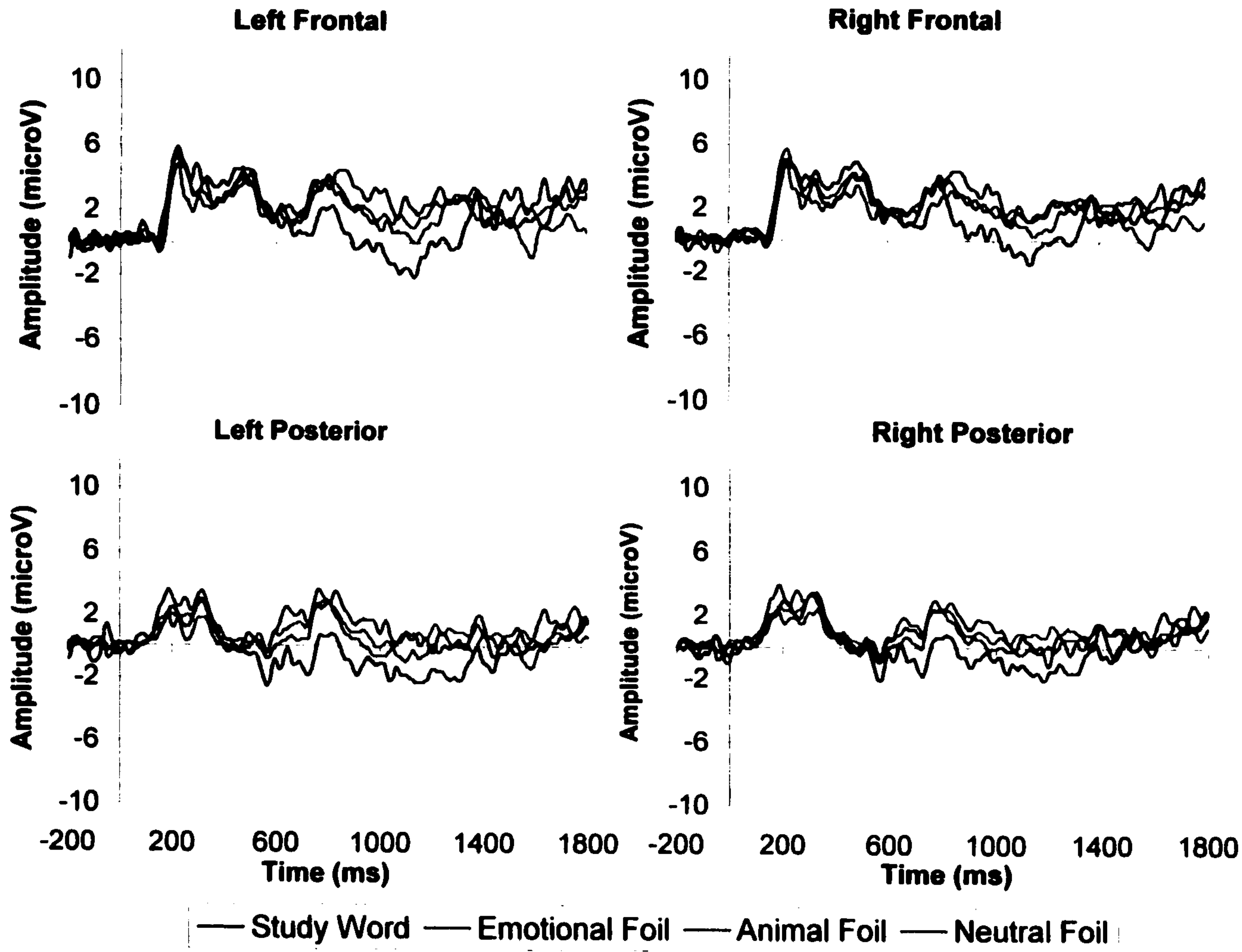
Note: Referenced to balanced ears, in older adults.

Figure 13. Distribution of ERP Waveforms Over Midline Sites in Experiment 3.



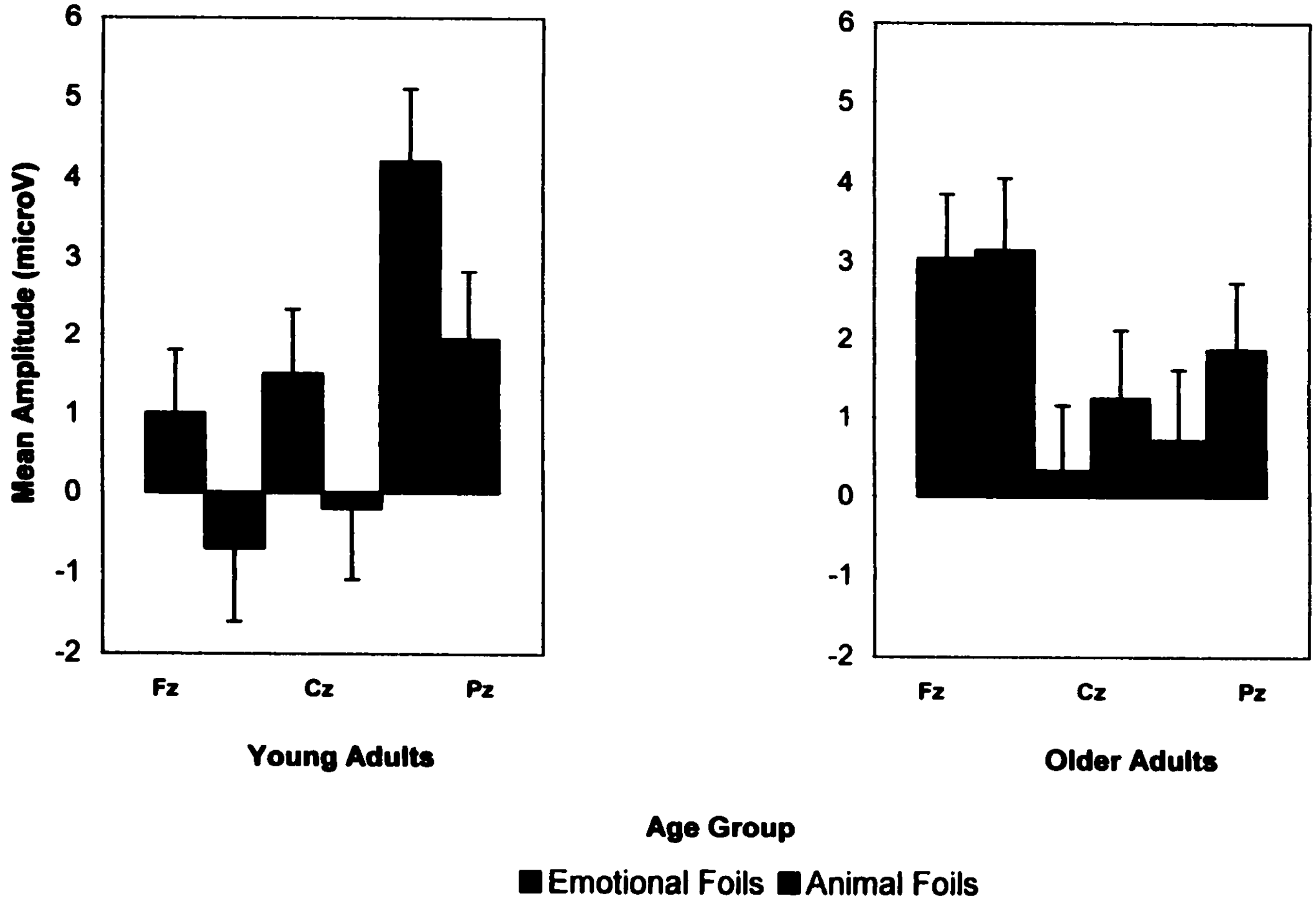
Note: Referenced to balanced ears, in older adults.

Figure 14. Distribution of ERP Waveforms Across Lateral Sites in Experiment 3.



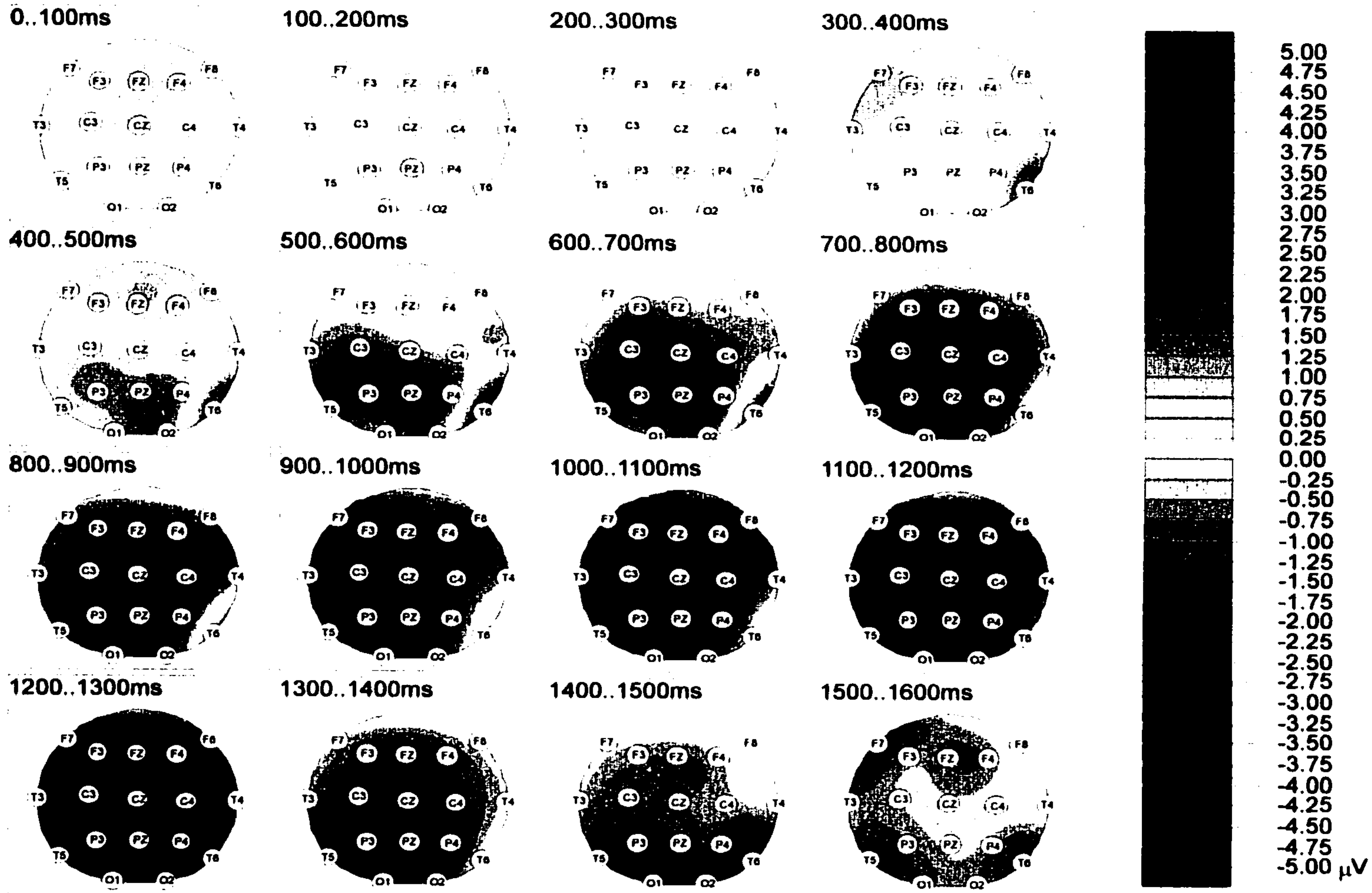
Note: Referenced to balanced ears, in older adults.

Figure 15. Three-Way Interaction between Age Group, Word Category and Site at midline sites in Experiment 3.



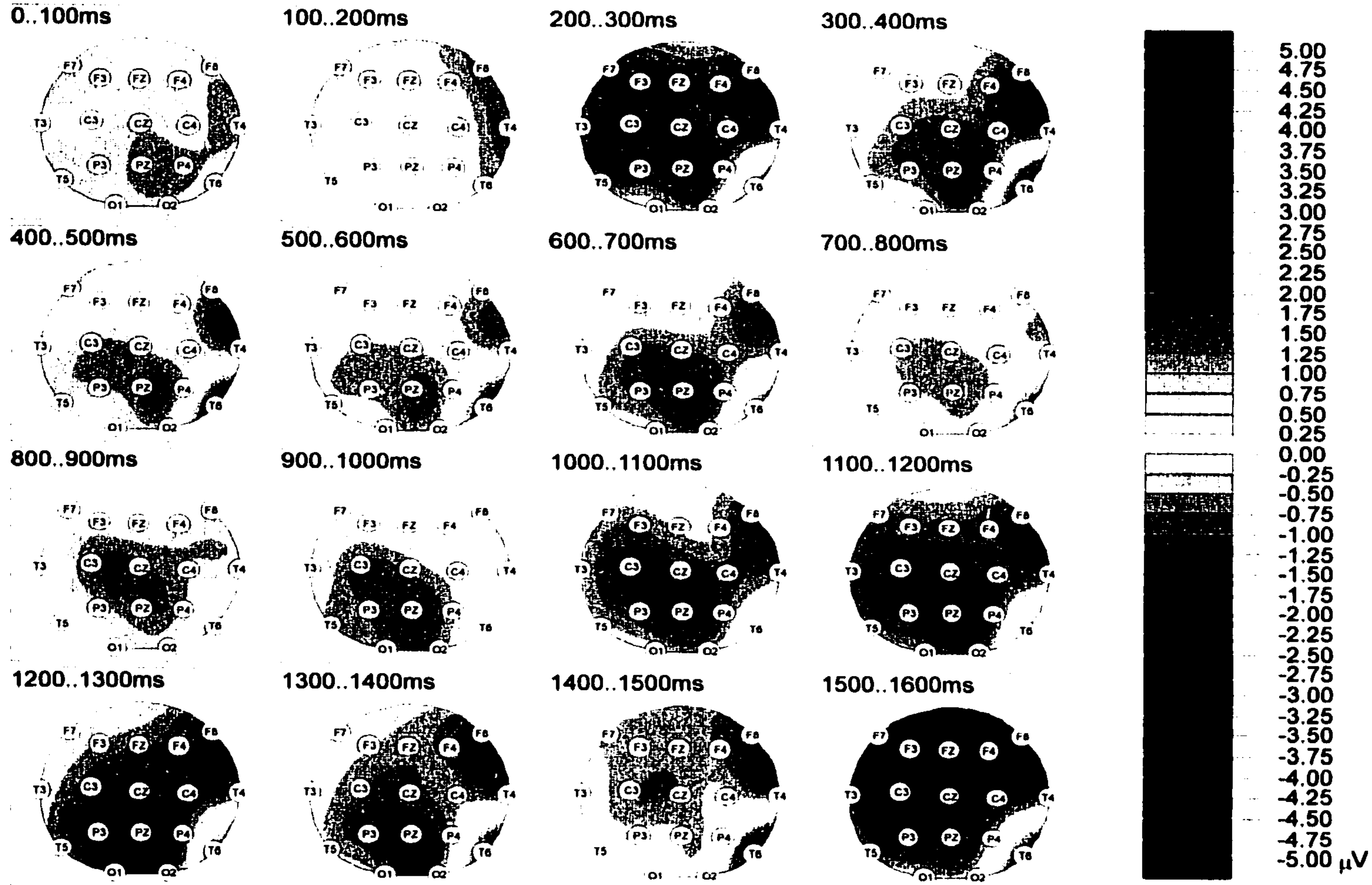
Note: Three-way interaction between age group, word category (emotional vs. animal foil) and site at midline sites for mean component 2 amplitude.

Figure 16. Temporal Sequence of Topographical Distribution of ERPs Elicited by Previous Occurrence in Older Adults in Experiment 3.



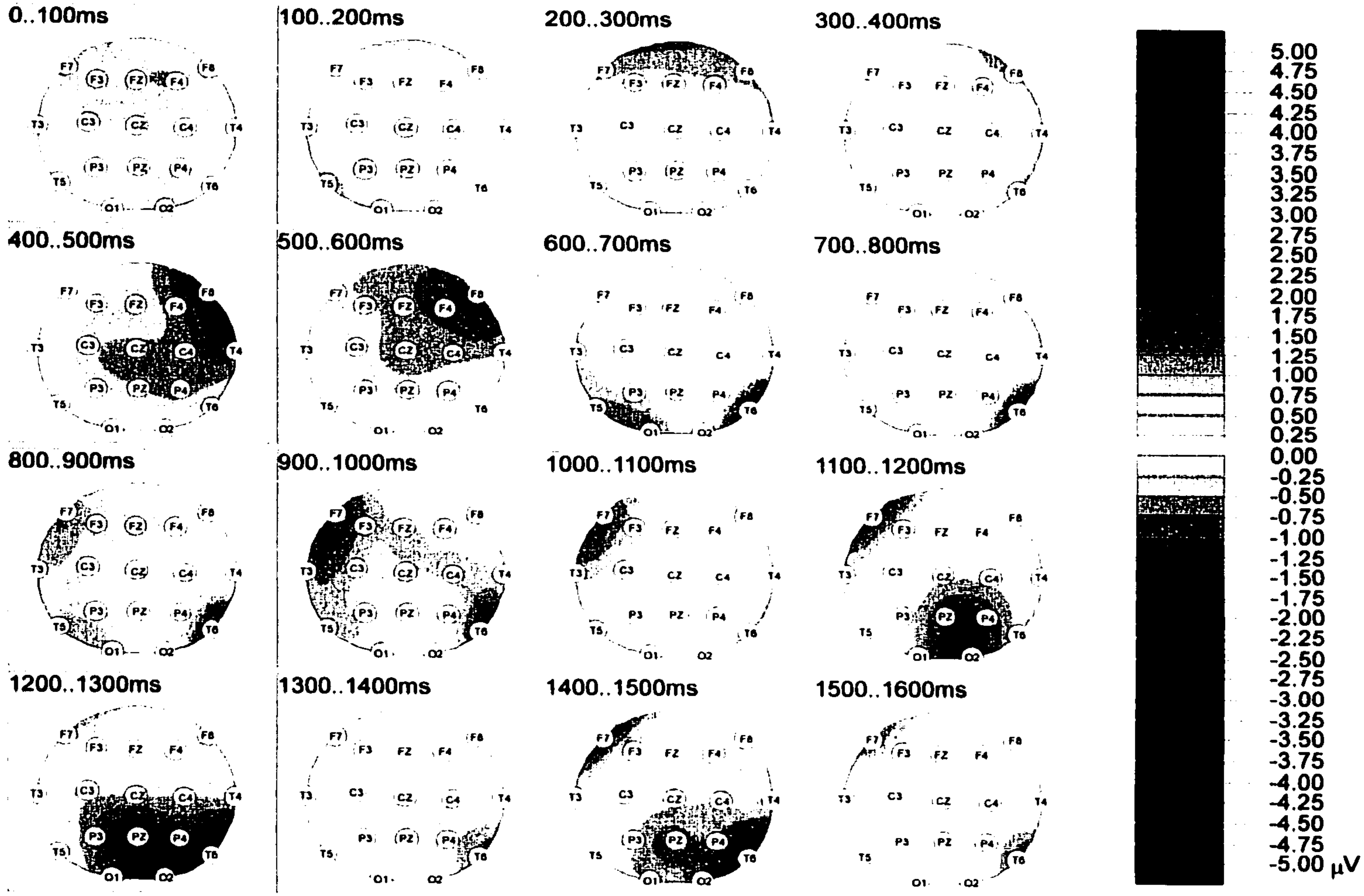
Note: Positive voltages are indicated in red and negative voltages are indicated in blue for ERP activity in successive 100 ms intervals from stimulus onset at 0 ms to 1600 ms. Scalp topographies are shown for difference waveforms derived by subtracting ERPs to neutral foils from ERPs to previously studied words, referenced to balanced ears. Orientation: Fz = front, Pz = back, T3 = left, T4 = right.

Figure 17. Temporal Sequence of Topographical Distribution of ERPs Elicited by Emotionality in Older Adults in Experiment 3.



Note: Positive voltages are indicated in red and negative voltages are indicated in blue for ERP activity in successive 100 ms intervals from stimulus onset at 0 ms to 1600 ms. Scalp topographies are shown for difference waveforms derived by subtracting ERP activity to neutral foils from ERP activity to emotional foils, referenced to balanced ears. Orientation: Fz = front, Pz = back, T3 = left, T4 = right.

Figure 18. Topographical Distribution of ERPs Elicited by the Animal Category in Older Adults in Experiment 3.



Note: Positive voltages are indicated in red and negative voltages are indicated in blue for ERP activity in successive 100 ms intervals from stimulus onset at 0 ms to 1600 ms. Scalp topographies are shown for difference waveforms derived by subtracting ERPs to neutral foils from ERPs to animal foils, referenced to balanced ears. Orientation: Fz = front, Pz = back, T3 = left, T4 = right.

Appendix A

ANOVA Source Tables

Appendix A-1: ANOVA Table for Repeated Measures ANOVA Within-Subject Effects of Previous Occurrence (Studied vs. Foil) and Emotionality (Emotional vs. Neutral) on Proportion of Words Judged to be from the Study List at Test for Experiment 1.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Prev. Occur.	3.16	3.16	1	115.54	.000	.91
Error	0.33	0.03	12			
Emotionality	0.17	0.17	1	8.75	.012	.42
Error	0.23	0.02	12			
Prev. Occur. x Emot.	0.003	0.003	1	0.36	.562	.03
Error	0.09	0.008	12			

Appendix A-2: ANOVA Table for Repeated Measures ANOVA: Within-Subject Effect of Previous Occurrence (Studied vs. Foil) and Emotionality (Emotional vs. Neutral) on LPC Amplitude (μV) at Lateral Sites for Experiment 1.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Prev. Occur.	239.95	239.95	1	2.71	.13	.18
Error	1063.69	88.64	12			
Emotionality	242.67	242.67	1	6.69	.03	.36
Error	435.30	36.28	12			
Lateral	36.50	36.50	1	4.22	.06	.26
Error	103.72	8.64	12			
Sagittal	3.52	3.52	1	0.07	.80	.01
Error	651.77	54.31	12			
Prev. Occur. x Emot.	2.79	2.79	1	0.04	.84	.00
Error	774.31	64.53	12			
Prev. Occur. x Lat.	0.36	0.36	1	0.29	.60	.02
Error	15.07	1.26	12			
Emot. x Lat.	0.001	0.001	1	0.001	.99	.00
Error	20.89	1.74	12			
Prev. Occur. x Emot. x Lat.	1.79	1.79	1	0.96	.35	.07
Error	22.34	1.86	12			
Prev. Occur. x Sag.	11.94	11.94	1	0.81	.39	.06
Error	176.25	14.69	12			
Emot. x Sag.	4.64	4.64	1	0.62	.45	.05
Error	89.42	7.45	12			
Prev. Occur. x Emot. x Sag.	0.45	0.45	1	0.11	.75	.01
Error	49.72	4.14	12			

Appendix A-2 Continued: Within-Subject Effects on LPC Amplitude at Lateral Sites

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Lat. x Sag.	0.19	0.19	1	0.09	.78	.01
Error	27.02	2.25	12			
Prev. Occur. x Lat. x Sag.	0.16	0.16	1	0.24	.63	.02
Error	8.08	0.67	12			
Emot. x Lat. x Sag.	0.91	0.91	1	1.96	.19	.14
Error	5.56	0.46	12			
Prev. Occur. x Emot. x Lat. x Sag.	0.69	0.69	1	1.30	.28	.10
Error	6.41	0.53	12			

Appendix A-3: ANOVA Table for Repeated Measures ANOVA: Within-Subject Effect of Previous Occurrence (Studied vs. Foil) and Emotionality (Emotional vs. Neutral) on LPC Amplitude (μV) at Frontal Sites for Experiment 1.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Prev. Occur.	258.23	258.23	1	6.86	.02	.36
Error	451.50	37.63	12			
Emotionality	46.50	46.50	1	4.39	.058	.29
Error	127.14	10.60	12			
Site	52.65	52.65	1	5.53	.04	.32
Error	114.33	9.53	12			
Prev. Occur x Emot	1.04	1.04	1	0.04	.84	.00
Error	294.47	24.54	12			
Prev. Occur x Site	7.91	7.91	1	3.22	.10	.21
Error	29.45	2.45	12			
Emot. x Site	4.11	4.11	1	1.25	.29	.09
Error	39.44	3.29	12			
Prev. Occur x Emot x Site	1.30	1.30	1	0.35	.56	.03
Error	44.25	3.69	12			

Appendix A-4: ANOVA Table for Repeated Measures ANOVA: Within-Subject Effect of Previous Occurrence (Studied vs. Foil) and Emotionality (Emotional vs. Neutral) on LPC Amplitude (μV) at Parietal Sites for Experiment 1.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Prev. Occur.	72.42	72.42	1	1.15	.31	.09
Error	759.24	63.27	12			
Emotionality	157.20	157.20	1	6.57	.025	.35
Error	287.32	23.94	12			
Site	15.69	15.69	1	4.59	0.53	.28
Error	41.04	3.42	12			
Prev. Occur x Emot.	0.50	0.50	1	0.02	.90	.00
Error	342.08	28.51	12			
Prev. Occur x Site	0.50	0.50	1	0.76	.40	.06
Error	7.94	0.66	12			
Emot. x Site	0.49	0.49	1	0.66	.43	.05
Error	8.88	0.74	12			
Prev. Occur. x Emot. x Site	0.13	0.13	1	0.24	.63	.02
Error	6.44	0.54	12			

Appendix A-5: ANOVA Table for Repeated Measures ANOVAWithin-Subject Effects of Previous Occurrence (Studied vs. Foil), Emotionality (Emotional vs. Neutral), Lateral Plane and Sagittal Plane on LC2 Amplitude at Lateral Sites for Experiment 1.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta²
Prev. Occur.	374.75	374.75	1	8.16	.01	.41
Error	551.20	45.93	12			
Emotionality	179.97	179.97	1	4.01	.07	.25
Error	538.58	44.88	12			
Lateral	30.38	30.38	1	4.93	.05	.29
Error	74.02	6.17	12			
Sagittal	55.23	55.23	1	1.66	.22	.12
Error	398.87	33.24	12			
Prev. Occur. x Emot.	16.51	16.51	1	0.29	.60	.02
Error	679.28	56.61	12			
Prev. Occur. x Lat.	0.71	0.71	1	0.30	.59	.03
Error	27.96	2.33	12			
Emot. x Lat.	1.37	1.39	1	0.80	.39	.06
Error	20.63	1.72	12			
Prev. Occur. x Emot. x Lat.	0.61	0.61	1	0.28	.60	.02
Error	25.59	2.13	12			
Prev. Occur. x Sag.	34.02	34.02	1	3.11	.10	.21
Error	131.29	10.94	12			
Emot. x Sag.	9.05	9.05	1	1.67	.22	.12
Error	65.19	5.43	12			
Prev. Occur. x Emot. x Sag.	0.24	0.24	1	0.06	.82	.01
Error	51.46	51.46	12			

Appendix A-5 Continued: Within-Subject Effects on LC2 Amplitude at Lateral Sites

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Lat. x Sag.	19.44	19.44	1	9.55	.01	.44
Error	24.42	2.04	12			
Prev. Occur. x Lat. x Sag.	0.26	0.26	1	0.22	.64	.02
Error	13.77	1.15	12			
Emot. x Lat. x Sag.	0.37	0.37	1	0.60	.46	.05
Error	7.34	0.61	12			
Prev. Occur. x Emot. x Lat. x Sag.	0.18	0.18	1	0.50	.49	.04
Error	4.36	0.36	12			

Appendix A-6: ANOVA Table for Repeated Measures ANOVAWithin-Subject Effect of Previous Occurrence (Studied vs. Foil) and Emotionality (Emotional vs. Neutral) on LC2 Amplitude (μV) at Midline Sites for Experiment 1.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Prev Occur	458.630	458.630	1	15.687	.002	.567
Error	350.843	29.237	12			
Emotionality	185.961	185.961	1	5.073	.044	.297
Error	439.923	36.660	12			
Site	91.315	65.764	1.39	5.477	.023	.313
Error	200.053	12.006	16.66			
Prev Occur x Emot	6.094	6.094	1	0.133	.722	.011
Error	549.491	45.791	12			
Prev Occur x Site	30.846	29.119	1.06	5.207	.039	.303
Error	71.095	5.593	12.71			
Emot x Site	0.746	0.546	1.37	0.197	.738	.016
Error	45.343	2.768	16.38			
P Occur x Emot x Site	0.934	0.467	2	0.396	.677	.032
Error	28.281	1.18	24			

Appendix A-7: ANOVA Table for Repeated Measures ANOVA Within-Subject Effect of Word Category (Studied word, Emotional, Animal and Neutral foil) on Proportion of Words Called Study at Test for Experiment 2.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Word Category	2.91	1.45	2.01	110.25	.000	.90
Error	0.32	0.01	24.17			

Appendix A-8: ANOVA Table for Repeated Measures ANOVA Within-Subject Effect of Word Category (Emotional vs. Animal foil), Lateral Plane and Sagittal Plane on Component 1 Amplitude (μV) at Lateral Sites for Experiment 2.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Word Category	39.47	39.47	1	8.40	.01	.41
Error	56.39	4.70	12			
Lateral	0.75	0.75	1	3.27	.10	.21
Error	2.76	0.23	12			
Sagittal	4.98	4.98	1	3.63	.08	.23
Error	16.47	1.37	12			
Word x Lat.	0.73	0.73	1	2.51	.14	.17
Error	3.47	0.29	12			
Word x Sag.	0.69	0.69	1	0.31	.59	.03
Error	26.64	2.22	12			
Lat. x Sag.	0.05	0.05	1	0.00	.95	.00
Error	1.67	0.14	12			
Word x Lat. x Sag.	0.44	0.44	1	2.11	.17	.15
Error	2.51	0.21	12			

Appendix A-9: ANOVA Table for Repeated Measures ANOVA Within-Subject Effect of Word Category (Emotional vs. Animal foils). Lateral Plane and Sagittal Plane on Component 2 Amplitude (μV) at Lateral Sites for Experiment 2.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Word Category	90.11	90.11	1	3.57	.08	.23
Error	302.84	25.24	12			
Lateral	0.31	0.31	1	0.13	.73	.01
Error	28.68	2.39	12			
Sagittal	179.27	179.27	1	25.96	.000	.68
Error	82.87	6.91	12			
Word x Lat.	0.08	0.08	1	0.07	.80	.01
Error	13.89	1.16	12			
Word x Sag.	0.03	0.03	1	0.02	.90	.00
Error	24.77	2.06	12			
Lat. x Sag.	0.94	....0.94	1	0.75	.40	.06
Error	15.02	1.25	12			
Word x Lat. x Sag.	0.50	0.50	1	3.79	.08	.24
Error	1.58	0.13	12			

Appendix A-10: ANOVA Table for Repeated Measures ANOVA Within-Subject Effect of Word Category (Studied word, Emotional, Animal and Neutral foils), Lateral Plane and Sagittal Plane on Component 3 (LPC) Amplitude (μV) at Lateral Sites for Experiment 2.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Word Category	750.93	250.31	3	12.66	.000	.51
Error	711.64	19.77	36			
Lateral	2.08	2.08	1	0.78	.40	.06
Error	32.04	2.67	12			
Sagittal	207.50	207.50	1	11.83	.005	.50
Error	210.44	17.54	12			
Word x Lat.	1.25	0.42	3	0.47	.71	.04
Error	31.93	0.89	36			
Word x Sag.	20.91	6.97	3	2.00	.13	.14
Error	125.49	3.49	36			
Lat. x Sag.	5.55	5.55	1	2.22	.16	.16
Error	29.99	2.50	12			
Word x Lat. x Sag.	1.35	0.45	3	1.71	.18	.13
Error	9.50	0.26	36			

Appendix A-11: ANOVA Table for Repeated Measures ANOVA Within-Subject Effect of Word Category (Studied word, Emotional, Animal and Neutral foils) and Frontal Site (Left vs. Right) on Component 3 (LPC) Amplitude (μV) for Experiment 2.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Word Category	284.99	95.00	3	8.74	.000	.42
Error	391.11	10.86	36			
Site	7.21	7.21	1	3.32	.094	.22
Error	26.06	2.17	12			
Word x Site	1.73	0.58	3	0.80	.50	.06
Error	25.96	0.72	36			

Appendix A-12: ANOVA Table for Repeated Measures ANOVA Within-Subject Effect of Word Category (Studied word, Emotional, Animal and Neutral foils) and Parietal Site (Left vs. Right) on Component 3 (LPC) Amplitude (μV) for Experiment 2.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Word Category	486.85	162.28	3	13.10	.000	.52
Error	446.01	12.39	36			
Site	0.42	0.42	1	0.14	.72	.01
Error	35.97	3.00	12			
Word x Site	0.88	0.29	3	0.70	.57	.05
Error	15.47	0.43	36			

Appendix A-13: ANOVA Table for Repeated Measures ANOVA Within-Subject Effects of Word Type (Studied word vs. Emotional foil), Lateral Plane and Sagittal Plane on Component 4 Amplitude (μV) at Lateral Sites for Experiment 2.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta²
Word Type	168.29	168.29	1	6.64	.02	.36
Error	303.97	25.33	12			
Lateral	24.25	24.25	1	7.46	.02	.38
Error	39.02	3.25	12			
Sagittal	289.65	289.65	1	31.25	.000	.72
Error	111.24	9.27	12			
Word x Lat.	2.95	2.95	1	2.94	.11	.20
Error	12.07	1.01	12			
Word x Sag.	5.99	5.99	1	1.79	.21	.13
Error	40.12	3.34	12			
Lat. x Sag.	11.78	11.78	1	6.85	.02	.36
Error	20.63	1.72	12			
Word x Lat.x Sag.	0.03	0.03	1	0.071	.80	.01
Error	5.94	0.50	12			

Appendix A-14: ANOVA Table for Repeated Measures ANOVA Within-Subject Effect of Word Category (Studied word. Emotional. Animal and Neutral foil) on Proportion of Words Called "Study" at Test for Older Adults for Experiment 3.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Word Category	1.80	0.60	3	61.73	.000	.84
Error	0.35	0.01	36			

Appendix A-15: ANOVA Table for Mixed Repeated Measures ANOVA Within-Subject Effect of Word Category (Studied word. Emotional, Animal and Neutral foil) on Proportion of Words Judged to be from the Study List Between Age Groups for Experiment 3.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Word Category	4.55	1.80	2.54	164.02	.000	.87
Word x Group	0.16	0.05	3	5.62	.002	.19
Error	0.67	0.01	60.90			

Between-Subjects Effect: Younger vs. Older Adults

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Intercept	7.79	7.79	1	191.50	.000	.89
Group	0.01	0.01	1	0.18	.673	.01
Error	0.98	0.04	24			

Appendix A-16: ANOVA Table for Repeated Measures ANOVA Within-Subject Effect of Word Category (Emotional vs. Animal Foil), Lateral Plane and Sagittal Plane on Component 1 Amplitude (μV) at Lateral Sites in Older Adults for Experiment 3.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Word Category	0.03	0.03	1	0.01	.95	.00
Error	71.90	5.99	12			
Lateral	0.09	0.09	1	0.36	.56	.03
Error	3.05	0.25	12			
Sagittal	0.72	0.72	1	1.55	.24	.11
Error	5.58	0.47	12			
Word x Lat.	0.02	0.02	1	0.07	.80	.01
Error	3.08	0.26	12			
Word x Sag.	0.41	0.41	1	0.58	.46	.05
Error	8.57	0.71	12			
Lat. x Sag.	0.34	0.34	1	6.17	.03	.34
Error	0.66	0.05	12			
Word x Lat. x Sag.	0.01	0.01	1	0.12	.73	.01
Error	0.82	0.07	12			

Appendix A-17: ANOVA Table for Repeated Measures ANOVA Within-Subject Effect of Word Category (Emotional vs. Animal Foil), Lateral Plane and Sagittal Plane on Component 2 Amplitude (μV) at Lateral Sites for Older Adults for Experiment 3.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Word Category	7.85	7.85	1	1.02	.33	.08
Error	92.80	7.73	12			
Lateral	0.0002	0.0002	1	0.00	.99	.00
Error	23.95	2.00	12			
Sagittal	57.21	57.21	1	8.16	.01	.41
Error	84.14	7.01	12			
Word x Lat.	0.41	0.41	1	1.58	.23	.12
Error	3.13	0.26	12			
Word x Sag.	2.04	2.04	1	1.62	.23	.12
Error	15.10	1.26	12			
Lat. x Sag.	0.50	0.50	1	0.52	.49	.04
Error	11.54	0.96	12			
Word x Lat. x Sag.	0.20	0.20	1	1.97	.19	.14
Error	1.19	0.10	12			

Appendix A-18: ANOVA Table for Mixed Design Repeated Measures ANOVA Within-Subject Effect of Word Category (Emotional vs. Animal foil). Lateral Plane and Sagittal Plane on Component 2 Amplitude (μV) Between Age Groups at Lateral Sites for Experiment 3.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Word Category	22.39	22.39	1	1.36	.26	.05
Word x Group	75.57	75.57	1	4.58	.04	.16
Error	395.64	16.49	24			
Lateral	0.16	0.16	1	0.07	.79	.00
Lat. x Group	0.15	0.15	1	0.07	.80	.00
Error	52.63	2.19	24			
Sagittal	16.97	16.97	1	2.44	.13	.09
Sag. x Group	219.51	219.51	1	31.55	.000	.57
Error	167.01	6.96	24			
Word x Lat.	0.43	0.43	1	0.60	.45	.02
Word x Lat. x Group	0.06	0.06	1	0.91	.77	.00
Error	17.02	0.71	24			
Word x Sag.	1.29	1.29	1	0.78	.39	.03
Word x Sag. x Group	0.78	0.78	1	0.47	.50	.02
Error	39.87	1.66	24			
Lat. x Sag.	0.03	0.03	1	0.03	.86	.00
Lat. x Sag. x Group	1.40	1.40	1	1.26	.27	.05
Error	26.56	1.11	24			
Word x Lat. x Sag.	0.03	0.03	1	0.30	.59	.01
Word x Lat. x Sag. x Group	0.66	0.66	1	5.72	.03	.19
Error	2.77	0.12	24			

Appendix A-18 Continued: Mixed Repeated Measures ANOVA on Component 2 Amplitude in Experiment 3.

Between-Subjects Effect: Younger vs. Older Adults

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Intercept	698.64	698.64	1	15.78	.001	.40
Group	5.30	5.30	1	0.12	.732	.01
Error	1062.93	44.29	24			

Appendix A-19: ANOVA Table for Repeated Measures ANOVA Within-Subject Effect of Word Category (Emotional vs. Animal Foil) and Site on Component 2 Amplitude (μV) at Midline Sites for Older Adults for Experiment 3.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Word Category	10.29	10.29	1	1.80	.20	.13
Error	68.41	5.70	12			
Site	77.34	38.67	2	14.80	.00	.55
Error	62.73	2.61	24			
Word x Site	3.96	2.72	1.45	4.08	.046	.25
Error	11.65	0.67	17.46			

Appendix A-20: ANOVA Table for Mixed Design Repeated Measures ANOVA Within-Subject Effect of Word Category (Emotional vs. Animal foil) and Site on Component 2 Amplitude (μV) between Age Groups at Midline Sites for Experiment 3.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Word Category	13.13	13.13	1	1.00	.33	.04
Word x Group	66.58	66.58	1	5.07	.03	.18
Error	314.95	13.12	24			
Site	56.92	34.14	1.67	10.00	.001	.29
Site x Group	147.34	73.67	2	25.89	.000	.52
Error	136.57	3.41	40.01			
Word x Site	1.09	0.70	1.56	1.00	.36	.04
Word x Site x Group	4.18	2.09	2	3.83	.03	.14
Error	26.21	0.70	37.36			

Between-Subjects Effect: Younger vs. Older Adults

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Intercept	354.14	354.14	1	9.11	.006	.28
Group	7.18	7.18	1	0.19	.671	.01
Error	933.54	38.90	24			

Appendix A-21: ANOVA Table for Repeated Measures ANOVA Within-Subject Effect of Word Category (Studied word, Emotional, Animal and Neutral foils), Lateral Plane and Sagittal Plane on Component 3 Amplitude (μV) at Lateral Sites for Older Adults for Experiment 3.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Word Category	188.30	91.17	2.06	4.04	.03	.25
Error	558.76	22.55	24.78			
Lateral	0.18	0.18	1	0.09	.77	.01
Error	24.58	2.05	12			
Sagittal	88.94	88.94	1	4.32	.06	.27
Error	246.99	20.58	12			
Word x Lat.	2.80	0.94	3	1.76	.17	.13
Error	19.11	0.53	36			
Word x Sag.	0.89	0.30	3	0.12	.95	.01
Error	87.36	2.43	36			
Lat. Sag.	0.50	0.50	1	0.19	.68	.02
Error	32.48	2.71	12			
Word x Lat. x Sag.	0.13	0.04	3	0.20	.90	.02
Error	7.60	0.21	36			

Appendix A-22: ANOVA Table for Mixed Design Repeated Measures ANOVA Within-Subject Effect of Word Category (Studied word. Emotional. Animal and Neutral foils). Lateral Plane and Sagittal Plane on Component 3 Amplitude (μV) Between Age Groups at Lateral Sites for Experiment 3.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Word	138.97	46.32	3	2.63	.06	.10
Word x Group	800.26	266.75	3	15.12	.000	.39
Error	1270.4	17.64	72			
Lateral	1.74	1.74	1	0.74	.40	.03
Lat. x Group	0.52	0.52	1	0.22	.65	.01
Error	56.62	2.36	24			
Sagittal	12.37	12.37	1	0.65	.43	.03
Sag. x Group	284.07	284.07	1	14.90	.001	.38
Error	457.44	19.06	24			
Word x Lat.	3.28	1.09	3	1.54	.21	.06
Word x Lat. x Group	0.77	0.26	3	0.36	.78	.02
Error	51.04	0.71	72			
Word x Sag.	8.26	2.76	3	0.93	.43	.04
Word x Sag. x Group	13.53	4.51	3	1.53	.22	.06
Error	212.85	2.96	72			
Lat. x Sag.	4.69	4.69	1	1.80	.19	.07
Lat. x Sag. x Group	1.36	1.36	1	0.52	.48	.02
Error	62.47	2.60	24			
Word x Lat. x Sag.	0.57	0.23	2.47	0.80	.50	.03
Word x Lat. x Sag. x Group	0.91	0.30	3	1.28	.29	.05
Error	17.10	0.30	59.21			

Appendix A-22 Continued: Mixed Repeated Measures ANOVA on Component 3 Amplitude at Lateral Sites for Experiment 3.

Between-Subject Effect: Younger vs. Older Adults

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Intercept	1308.52	1308.52	1	12.98	.001	.35
Group	11.41	11.41	1	0.11	.74	.01
Error	2419.41	100.81	24			

Appendix A-23: ANOVA Table for Repeated Measures ANOVA Within-Subject Effect of Word Category (Studied word. Emotional. Animal and Neutral foils) and Site on Component 3 Amplitude (μV) at Midline Sites for Older Adults for Experiment 3.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Word Category	225.81	75.27	3	6.31	.001	.35
Error	429.21	11.92	36			
Site	102.10	74.53	1.37	6.65	.01	.36
Error	184.26	11.21	16.44			
Word x Site	7.01	1.96	3.58	1.23	.31	.09
Error	68.63	1.60	43.01			

Appendix A-24: ANOVA Table for Repeated Measures ANOVA Within-Subject Effect of Word Category (Studied word, Emotional, Animal and Neutral foils) and Frontal Site (Left vs. Right) on Component 3 (LPC) Amplitude (μV) for Older Adults for Experiment 3.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Word Category	83.21	40.91	2.03	2.26	.13	.16
Error	441.30	18.08	24.41			
Site	0.64	0.64	1	0.20	.66	.02
Error	38.59	3.22	12			
Word x Site	1.55	0.52	3	1.11	.36	.09
Error	16.73	0.47	36			

Appendix A-25: ANOVA Table for Repeated Measures ANOVA Within-Subject Effect of Word Category (Studied word, Emotional, Animal and Neutral foils) and Parietal Site (Left vs. Right) on Component 3 (LPC) Amplitude (μV) for Older Adults for Experiment 3.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Word Category	105.98	51.89	2.04	6.21	.006	.34
Error	204.82	24.51	24.51			
Site	0.04	0.04	1	0.26	.88	.00
Error	18.47	1.54	12			
Word x Site	1.38	0.46	3	1.66	.19	.12
Error	9.97	0.28	36			

Appendix A-26: ANOVA Table for Repeated Measures ANOVA Within-Subject Effect of Word Category (Studied word vs. Animal foil). Lateral Plane and Sagittal Plane on Component 4 Amplitude (μV) at Lateral Sites for Older Adults for Experiment 3.

Within-Subject Effects

Source	Sum of Squares	Mean Square	df	F	p	Eta^2
Word Category	147.18	147.18	1	16.85	.001	.58
Error	104.80	8.73	12			
Lateral	0.05	0.05	1	0.03	.87	.00
Error	21.45	1.79	12			
Sagittal	63.43	63.43	1	2.83	.12	.19
Error	268.57	22.38	12			
Word x Lat.	3.95	3.95	1	3.16	.10	.21
Error	14.98	1.25	12			
Word x Sag.	1.54	1.54	1	1.08	.32	.08
Error	17.17	1.43	12			
Lat. Sag.	0.06	0.06	1	0.03	.86	.00
Error	20.36	1.70	12			
Word x Lat. x Sag.	0.02	0.02	1	0.11	.74	.01
Error	2.33	0.19	12			

Appendix B

Tables listing mean ERP component amplitude

Appendix B-1: Mean (SD) LPC Amplitude (μV) for each Test Word Category by Site in Young Adults in Experiment 1.

	Study Words		Foil Words	
Site	Emotional	Neutral	Emotional	Neutral
Fz	5.28 (3.12)	2.91 (6.87)	2.41 (4.83)	0.70 (2.36)
Cz	6.67 (4.50)	3.39 (6.01)	3.84 (4.85)	1.59 (2.27)
Pz	6.70 (5.63)	3.07 (6.01)	4.95 (4.51)	2.26 (2.18)
F3	5.00 (3.41)	3.25 (6.77)	2.38 (4.28)	0.67 (1.92)
F4	6.36 (2.72)	3.74 (6.76)	3.08 (5.32)	1.71 (2.87)
F7	2.11 (3.54)	1.00 (6.87)	1.91 (3.71)	0.58 (1.99)
F8	5.61 (3.77)	3.33 (5.59)	3.54 (5.19)	2.51 (3.47)
C3	5.16 (4.92)	2.09 (6.51)	2.57 (4.18)	0.74 (1.81)
C4	7.50 (3.34)	4.29 (5.72)	3.97 (4.38)	2.44 (2.12)
T3	3.08 (3.83)	0.82 (5.60)	1.55 (3.25)	0.61 (1.30)
T4	4.13 (1.55)	2.25 (4.24)	2.19 (3.35)	1.51 (1.36)
T5	2.07 (4.97)	0.14 (5.87)	0.71 (3.36)	-1.09 (2.15)
T6	3.54 (5.28)	0.60 (5.42)	0.82 (4.28)	-0.89 (1.49)
P3	5.24 (5.88)	2.58 (6.31)	3.64 (4.08)	1.12 (2.14)
P4	6.09 (4.99)	3.56 (6.07)	4.08 (4.82)	1.96 (2.15)
O1	2.27 (5.55)	0.25 (7.34)	1.78 (3.79)	-0.92 (2.40)
O2	1.78 (5.80)	-0.26 (6.58)	1.36 (4.48)	-0.99 (2.77)

Appendix B-2: Mean (SD) LC2 Amplitude (μV) for each Test Word Category by Site in Young Adults for Experiment 1.

	Study Words		Foil Words	
Site	Emotional	Neutral	Emotional	Neutral
Fz	0.92 (4.11)	-0.83 (5.16)	3.69 (5.75)	0.75 (2.43)
Cz	-0.91 (3.64)	-2.73 (4.61)	3.45 (5.34)	0.88 (3.07)
Pz	-1.91 (3.66)	-3.70 (3.68)	2.43 (4.82)	0.21 (2.53)
F3	0.86 (4.07)	-1.05 (5.69)	3.22 (5.71)	0.42 (2.70)
F4	0.93 (3.91)	-0.73 (5.52)	3.30 (5.54)	0.55 (2.12)
F7	0.35 (4.01)	-0.93 (6.20)	2.17 (4.81)	0.28 (2.30)
F8	2.13 (4.01)	0.33 (4.79)	2.70 (5.23)	0.84 (1.51)
C3	-1.05 (3.40)	-3.09 (4.71)	2.18 (5.00)	0.04 (2.43)
C4	0.18 (3.58)	-0.77 (4.00)	2.87 (4.37)	0.58 (2.30)
T3	-0.13 (3.30)	-1.74 (4.75)	1.09 (3.81)	-0.07 (1.09)
T4	0.96 (2.61)	0.38 (3.01)	1.81 (3.03)	0.56 (1.26)
T5	-1.80 (3.70)	-2.63 (4.12)	1.05 (4.20)	-0.74 (1.78)
T6	0.18 (4.46)	-0.80 (4.79)	2.31 (5.74)	-0.50 (2.53)
P3	-2.01 (3.60)	-3.23 (4.01)	2.14 (4.59)	-0.02 (2.25)
P4	-0.86 (4.19)	-1.26 (4.45)	3.25 (5.28)	1.25 (2.80)
O1	-2.51 (4.00)	-3.15 (5.36)	1.81 (4.62)	-0.21 (2.46)
O2	-2.01 (4.42)	-2.77 (4.64)	1.91 (5.09)	0.15 (2.83)

Appendix B-3: Mean (SD) Component 1 Amplitude (μV) for each Test Word Category by Site in Young Adults for Experiment 2.

	Study Words	Foil Words		
Site		Emotional	Animal	Neutral
Fz	-0.38 (1.78)	0.45 (2.08)	-0.85 (2.00)	-0.57 (1.21)
Cz	0.06 (2.25)	0.61 (2.22)	-0.74 (2.52)	-0.64 (1.09)
Pz	0.39 (2.44)	0.71 (2.13)	-0.53 (2.20)	-0.45 (1.15)
F3	-0.58 (2.110	0.34 (2.13)	-0.76 (2.14)	-0.47 (1.27)
F4	-0.40 (1.70)	0.81 (1.92)	-0.88 (2.29)	-0.50 (1.21)
F7	-0.61 (1.50)	0.47 (1.79)	-0.47 (2.26)	-0.37 (1.13)
F8	-0.21 (1.87)	0.68 (1.73)	-0.67 (2.18)	-0.31 (0.99)
C3	-0.14 (2.20)	0.48 (2.24)	-0.57 (2.35)	-0.58 (1.07)
C4	0.20 (2.26)	0.94 (2.03)	-0.55 (2.29)	-0.45 (1.09)
T3	-0.08 (1.71)	0.36 (1.84)	-0.42 (2.05)	-0.22 (0.89)
T4	0.33 (1.46)	0.55 (1.34)	-0.47 (1.90)	-0.20 (0.78)
T5	0.64 (1.99)	0.76 (1.98)	0.08 (2.11)	0.00 (0.95)
T6	1.28 (4.12)	1.07 (2.35)	-0.23 (3.32)	0.61 (1.46)
P3	0.47 (2.33)	0.75 (2.10)	-0.28 (2.29)	-0.25 (1.11)
P4	0.85 (2.32)	0.95 (1.97)	-0.16 (2.10)	-0.02 (1.13)
O1	0.82 (1.90)	0.45 (1.84)	0.20 (2.03)	0.01 (1.32)
O2	1.35 (1.85)	0.79 (1.67)	0.67 (2.16)	0.33 (1.55)

Appendix B-4: Mean (SD) Component 2 Amplitude (μV) for each Test Word Category by Site in Young Adults for Experiment 2.

	Study Words	Foil Words		
Site		Emotional	Animal	Neutral
Fz	0.99 (3.84)	1.00 (3.50)	-0.70 (3.96)	-0.17 (2.16)
Cz	1.85 (3.93)	1.50 (3.38)	-0.20 (4.02)	-0.03 (2.13)
Pz	4.11 (5.02)	4.20 (3.86)	1.95 (4.02)	1.98 (2.93)
F3	0.50 (3.91)	1.17 (3.07)	-0.53 (3.92)	0.10 (2.07)
F4	0.97 (4.09)	1.45 (3.16)	-0.64 (4.39)	0.18 (2.01)
F7	-0.46 (3.78)	1.59 (2.30)	-0.28 (4.05)	0.25 (2.03)
F8	0.86 (3.48)	1.20 (1.92)	-0.36 (3.42)	0.07 (1.90)
C3	1.32 (3.75)	1.69 (3.17)	-0.05 (4.01)	0.26 (2.16)
C4	1.92 (4.05)	2.05 (3.00)	0.17 (3.51)	0.70 (1.51)
T3	0.33 (3.52)	1.47 (2.53)	-0.01 (3.71)	0.34 (1.60)
T4	1.18 (3.10)	0.94 (2.27)	-0.18 (2.94)	0.24 (1.29)
T5	2.73 (4.23)	3.08 (3.15)	1.75 (4.06)	1.67 (2.37)
T6	4.07 (5.08)	2.43 (2.85)	0.65 (4.08)	2.23 (2.58)
P3	3.87 (4.770	4.09 (3.70)	2.18 (4.33)	2.19 (2.96)
P4	4.07 (4.49)	3.71 (3.32)	1.97 (3.45)	2.16 (2.15)
O1	4.47 (4.85)	4.47 (3.81)	3.48 (4.02)	2.94 (3.15)
O2	5.08 (4.14)	4.42 (3.18)	3.33 (3.40)	3.17 (3.05)

Appendix B-5: Mean (SD) Component 3 LPC Amplitude (μV)for each Test Word Category by Site in Young Adults for Experiment 2.

	Study Words	Foil Words		
Site		Emotional	Animal	Neutral
Fz	3.69 (3.66)	-0.17 (4.05)	-0.46 (4.20)	-0.14 (2.71)
Cz	5.30 (3.50)	0.76 (3.93)	0.56 (4.24)	0.38 (2.62)
Pz	6.49 (3.65)	2.33 (2.79)	1.81 (4.13)	1.20 (2.55)
F3	3.30 (3.99)	-0.24 (3.89)	-0.45 (4.10)	0.10 (2.96)
F4	4.27 (4.01)	0.22 (3.73)	-0.15 (4.80)	0.47 (2.75)
F7	1.88 (4.00)	-0.04 (3.12)	-0.67 (4.29)	0.14 (3.25)
F8	3.66 (3.86)	1.11 (3.08)	0.73 (4.02)	1.28 (3.07)
C3	4.49 (3.60)	0.63 (3.33)	0.32 (4.54)	0.46 (2.74)
C4	5.50 (3.69)	1.08 (3.27)	1.02 (4.11)	1.06 (2.45)
T3	3.67 (3.19)	1.28 (2.56)	0.72 (4.22)	1.21 (2.34)
T4	3.86 (3.29)	0.98 (2.55)	1.04 (3.59)	1.39 (2.44)
T5	5.26 (3.47)	1.45 (1.73)	1.36 (4.34)	1.02 (2.05)
T6	3.51 (5.01)	0.04 (2.92)	0.27 (4.79)	1.26 (3.49)
P3	6.71 (3.75)	2.07 (2.50)	1.81 (4.71)	1.42 (2.75)
P4	6.64 (3.76)	1.63 (2.92)	1.85 (4.20)	1.38 92.58)
O1	5.75 (3.43)	1.16 (2.06)	1.81 (4.01)	0.55 (1.95)
O2	4.71 (3.26)	0.29 (2.94)	1.04 (4.14)	0.15 (2.18)

Appendix B-6: Mean (SD) Component 4 Amplitude (µV) for each Test Word Category by Site in Young Adults for Experiment 2.

	Study Words	Foil Words		
Site		Emotional	Animal	Neutral
Fz	1.03 (5.79)	3.27 (4.87)	2.20 (4.93)	3.09 (4.15)
Cz	-1.93 (6.27)	1.71 (3.79)	0.28 (4.53)	1.18 (4.30)
Pz	-4.33 (6.86)	-0.06 (3.68)	-1.97 (4.47)	-0.92 (3.66)
F3	0.53 (5.99)	2.89 (4.56)	1.82 (4.73)	2.91 (4.26)
F4	1.12 (6.05)	2.89 (4.43)	1.86 (5.18)	2.87 (4.05)
F7	0.40 (4.63)	2.88 (4.00)	1.02 (4.46)	1.97 (3.92)
F8	1.91 (5.66)	3.45 (4.03)	2.67 (5.69)	3.37 (4.57)
C3	-2.41 (6.03)	1.07 (3.75)	-0.37 (4.54)	0.70 (4.13)
C4	-0.98 (5.89)	2.07 (3.75)	0.55 (4.99)	1.52 (4.48)
T3	-1.42 (4.49)	1.13 (3.04)	-0.34 (4.36)	0.29 (3.29)
T4	1.20 (5.14)	1.99 (2.64)	1.38 (4.80)	2.01 (4.04)
T5	-3.23 (5.85)	-1.05 (3.59)	-1.87 (4.57)	-1.25 (3.73)
T6	-1.06 (6.82)	0.63 (5.14)	-0.65 (7.55)	1.09 (6.83)
P3	-4.00 (6.78)	-0.60 (4.02)	-2.10 (5.03)	-0.98 (4.08)
P4	-1.99 (6.24)	0.66 (3.58)	-0.62 (5.24)	0.21 (4.41)
O1	-4.97 (7.44)	-2.19 (4.62)	-2.21 (5.19)	-1.99 (4.55)
O2	-3.51 (7.02)	-1.64 (3.95)	-1.48 (5.13)	-1.23 (4.74)

Appendix B-7: Mean (SD) Component 1 Amplitude (μV) for each Test Word Category by Site in Older Adults for Experiment 3.

Site	Study Words	Foil Words		
		Emotional	Animal	Neutral
Fz	0.19 (1.59)	0.21 (1.10)	0.04 (1.40)	0.57 (0.63)
Cz	0.24 (1.76)	0.07 (1.41)	0.26 (1.27)	0.52 (0.70)
Pz	0.31 (1.56)	0.04 (1.22)	0.34 (1.10)	0.56 (0.81)
F3	0.30 (1.83)	0.21 (1.15)	0.04 (1.46)	0.52 (0.55)
F4	0.22 (1.24)	0.15 (1.02)	0.00 (1.29)	0.57 (0.71)
F7	0.27 (1.44)	-0.06 (1.13)	0.02 (1.56)	0.35 (0.40)
F8	0.42 (1.23)	-0.08 (0.77)	0.12 (1.11)	0.52 (0.88)
C3	0.26 (1.97)	0.30 (1.26)	0.14 (1.05)	0.47 (0.58)
C4	0.55 (1.27)	0.21 (0.98)	0.33 (1.07)	0.54 (0.52)
T3	0.05 (0.95)	-0.03 (0.91)	0.21 (0.62)	0.24 (0.32)
T4	0.45 (0.77)	-0.27 (0.67)	0.11 (0.84)	0.44 (0.39)
T5	0.33 (1.20)	0.31 (0.90)	0.53 (0.58)	0.52 (0.52)
T6	0.76 (2.47)	0.57 (1.83)	0.50 (2.78)	0.94 (1.22)
P3	0.26 (1.60)	0.15 (1.10)	0.20 (0.97)	0.47 (0.64)
P4	0.56 (1.17)	0.28 (1.00)	0.42 (1.06)	0.77 (0.71)
O1	0.56 (1.21)	0.36 (0.82)	0.44 (0.82)	0.57 (0.71)
O2	0.73 (1.06)	0.58 (0.74)	0.49 (1.12)	0.91 (0.85)

Appendix B-8: Mean (SD) Component 2 Amplitude (μV) for each Test Word Category by Site in Older Adults for Experiment 3.

Site	Study Words	Foil Words Emotional	Animal	Neutral
Fz	3.38 (3.50)	3.05 (2.14)	3.15 (2.35)	3.31 (0.92)
Cz	0.52 (2.54)	0.32 (2.60)	1.24 (1.99)	1.12 (1.48)
Pz	0.46 (1.30)	0.71 (2.48)	1.86 (1.99)	1.64 (1.70)
F3	3.04 (3.59)	2.65 (1.89)	2.96 (2.72)	3.01 (0.96)
F4	3.13 (3.34)	2.54 (1.90)	2.78 (1.86)	3.23 (1.08)
F7	2.55 (2.88)	2.28 (1.48)	2.31 (2.77)	2.36 (1.33)
F8	2.98 (3.61)	1.98 (1.67)	2.21 (1.92)	2.96 (1.34)
C3	0.73 (2.21)	0.67 (2.22)	1.48 (2.00)	1.40 (1.24)
C4	1.56 (2.57)	1.29 (2.13)	1.90 (1.88)	1.92 (1.14)
T3	0.47 (1.06)	0.43 (1.15)	1.07 (1.30)	0.67 (0.65)
T4	1.08 (2.57)	0.52 (1.74)	0.95 (1.31)	1.26 (0.86)
T5	-0.75 (1.36)	-0.60 (2.35)	0.59 (1.63)	-0.22 (1.91)
T6	1.28 (3.22)	1.45 (3.10)	0.13 (4.02)	-0.29 (2.42)
P3	0.25 (0.97)	0.66 (2.55)	1.70 (1.61)	1.35 (1.83)
P4	0.77 (1.73)	1.01 (2.58)	1.63 (1.96)	1.52 (1.59)
O1	-0.22 (1.48)	0.15 (2.66)	1.14 (1.93)	0.28 (1.91)
O2	-0.24 (1.74)	0.10 (2.46)	0.80 (2.22)	0.32 (1.55)

Appendix B-9: Mean (SD) Component 3 LPC Amplitude (μV) for each Test Word Category by Site for Older Adults for Experiment 3.

	Study Words	Foil Words		
Site		Emotional	Animal	Neutral
Fz	1.00 (4.67)	2.60 (3.15)	3.73 (3.63)	3.14 (2.41)
Cz	-1.07 (4.02)	1.03 (3.10)	2.70 (3.05)	2.19 (2.82)
Pz	-0.98 (3.45)	0.27 (2.77)	1.98 (2.66)	1.55 (2.58)
F3	0.64 (5.14)	2.06 (3.08)	3.38 (4.23)	2.64 (2.32)
F4	1.16 (4.40)	2.12 (2.95)	3.23 (3.04)	2.84 (2.43)
F7	0.55 (4.26)	1.16 (2.43)	2.51 (4.51)	1.40 (2.15)
F8	2.42 (4.40)	2.29 (3.06)	3.23 (3.36)	3.07 (2.58)
C3	-0.61 (3.42)	1.00 (3.07)	2.78 (3.26)	2.13 (2.77)
C4	0.46 (3.63)	1.48 (2.83)	2.92 (2.65)	2.36 (2.31)
T3	0.60 (1.76)	1.10 (1.99)	2.28 (2.01)	1.39 (1.42)
T4	1.11 (2.97)	1.01 (2.05)	2.03 (1.84)	1.69 (1.60)
T5	-0.01 (2.43)	0.64 (2.53)	2.14 (1.93)	1.18 (1.87)
T6	1.08 (3.54)	0.91 (3.20)	2.16 (3.13)	0.42 (2.31)
P3	-0.68 (3.02)	0.65 (2.85)	2.31 (2.68)	1.62 (2.71)
P4	-0.40 (3.50)	0.67 (2.69)	1.95 (2.38)	1.51 (2.32)
O1	-1.07 (2.87)	-0.23 (2.15)	1.24 (2.07)	0.40 (2.19)
O2	-1.40 (3.21)	-0.54 (2.23)	0.68 (2.22)	0.15 (2.14)

Appendix B-10: Mean (SD) Component 4 Amplitude (μV) for each Test Word Category by Site for Older Adults for Experiment 3.

	Study Words	Foil Words		
Site		Emotional	Animal	Neutral
Fz	0.11 (5.05)	1.85 (3.22)	3.08 (4.23)	2.62 (3.34)
Cz	-1.36 (4.26)	0.27 (3.06)	1.64 (3.44)	1.57 (3.03)
Pz	-1.43 (3.73)	-0.50 (3.06)	0.74 (3.12)	1.01 (2.99)
F3	0.10 (5.46)	1.63 (2.94)	3.14 (4.81)	2.42 (3.09)
F4	0.51 (4.70)	1.64 (3.15)	2.72 (3.68)	2.54 (3.34)
F7	0.15 (4.90)	0.95 (2.38)	2.86 (5.25)	1.50 (2.79)
F8	2.06 (4.06)	2.04 (2.99)	3.22 (3.76)	3.18 (3.13)
C3	-0.99 (4.24)	0.34 (3.02)	1.88 (3.37)	1.55 (2.95)
C4	-0.28 (3.29)	0.71 (2.52)	1.70 (2.50)	1.63 (2.43)
T3	0.14 (2.24)	0.71 (1.85)	1.88 (2.02)	1.19 (1.51)
T4	0.61 (2.24)	0.57 (1.71)	1.36 (1.67)	1.34 (1.40)
T5	-0.07 (3.28)	0.69 (2.45)	1.91 (2.01)	1.36 (2.06)
T6	0.97 (2.81)	1.81 (2.85)	1.31 (4.53)	1.13 (1.99)
P3	-1.24 (3.64)	0.01 (3.07)	1.26 (2.95)	1.14 (3.06)
P4	-0.79 (3.47)	0.31 (2.88)	0.99 (2.66)	1.24 (2.79)
O1	-1.35 (3.54)	-0.25 (2.62)	0.71 (2.40)	0.50 (2.59)
O2	-1.39 (3.50)	-0.36 (2.54)	0.21 (2.55)	0.46 (2.55)

Appendix C

Word Rating Information

Appendix C-1: Word Rating Study

Rationale

This study was conducted in order to construct new study and test lists for Experiment 2. A list of animal names (e.g.. beaver, horse) was compiled and matched in terms of length and frequency in the English language to the sets of emotional and neutral words used in Exp. 1. A word rating task was conducted to ascertain that subjects would indeed categorize these words readily as "animal", and that they would also perceive the words intended to be emotional as such. Mean "animalness" and "emotionality" ratings were thus obtained and used in the construction of the study and test lists for experiment 2.

Methods and Procedure

Participants: Fifteen individuals (7 male) ranging in age from 16 to 71 years participated (mean age=32.93, SD=17.09).

Materials: 350 potential stimulus words were printed individually in black ink on white cards (2 x 3 inches). Two identical sets of cards were created, and participants were asked to sort the cards twice, according to 2 criteria. Animal rating condition: "how much like an animal is this word?" ; Emotion rating condition: "how emotional is this word to me?" Order of condition was counter-balanced across participants. Participants were asked to sort the cards on a scale from "0" not at all like animal (or not at all emotional) to "6" most like an animal (or most highly emotional). Each test session lasted approximately 30 to 45 minutes.

After each set of cards was sorted, ratings were recorded on a spreadsheet by the examiner. These ratings were then used to calculate mean emotionality and mean "animalness" ratings for each word. Any words that were rated as both highly emotional and animal-like (e.g., snake) were eliminated. Stimulus word sets for emotional words, animal words, and neutral words were then selected and used to create 6 matched versions of study (30 words) and test lists (280 words) for Experiment 2. These word lists were then entered into the INSTEP computer software system used for stimulus presentation and EEG data collection at the Brock Electrophysiology Lab.

Appendix C-2:Emotional Word Sets

Set 1

Word	Mean Rating
Dying	4.87
Abusive	4.13
Disgust	3.87
Terror	4.13
Attack	3.27
Jealous	3.27
Grand Mean	3.92 (SD = .61)

Set 2

Word	Mean Rating
Kill	4.60
Coffin	4.47
Enrage	3.40
Agony	3.67
Greed	3.60
Lonely	3.73
Grand Mean	3.91 (SD = .50)

Set 3

Word	Mean Rating
Morgue	4.60
Fear	4.27
Weapon	4.13
Sorry	3.93
Brutal	3.60
Insane	4.00
Grand Mean	4.09 (SD = .34)

Set 4

Word	Mean Rating
Mourn	4.73
Betray	4.00
Horror	3.73
Threat	4.00
Blood	4.20
Scream	3.73
Grand Mean	4.07 (SD = .37)

Set 5

Word	Mean Rating
Murder	4.53
Cancer	4.27
Hatred	4.13
Anger	3.80
Choke	3.73
Misery	3.67
Grand Mean	4.02 (SD = .34)

Set 6

Word	Mean Rating
Corpse	4.60
Panic	4.20
Hostile	3.73
Tragedy	4.20
Drown	3.60
Incest	3.60
Grand Mean	3.99 (SD = .41)

Appendix C-3:Animal Word Sets

Set 1

Word	Mean Rating
Buffalo	6.00
Possum	6.00
Walrus	5.47
Hound	5.47
Falcon	5.33
Duck	4.93
Grand Mean	5.53 (SD = .41)

Set 2

Word	Mean Rating
Otter	6.00
Deer	5.93
Kitten	5.93
Rooster	5.40
Hawk	5.33
Turtle	5.20
Grand Mean	5.63 (SD = .36)

Set 3

Word	Mean Rating
Ferret	6.00
Tiger	6.00
Calf	5.87
Dolphin	5.53
Peacock	5.33
Turkey	5.27
Grand Mean	5.27 (SD = .34)

Set 4

Word	Mean Rating
Cheetah	6.00
Rabbit	6.00
Mouse	5.60
Frog	5.33
Parrot	5.33
Goose	5.27
Grand Mean	5.67 (SD = .33)

Set 5

Word	Mean Rating
Horse	6.00
Sheep	6.00
Beaver	5.93
Poodle	5.60
Chicken	5.27
Robin	5.33
Grand Mean	5.69 (SD = .34)

Set 6

Word	Mean Rating
Lamb	6.00
Weasel	6.00
Monkey	5.93
Hyena	5.60
Pigeon	5.33
Catfish	4.93
Grand Mean	5.63 (SD = .43)

Appendix C-4:Neutral Study Word Sets

Set 1

Word	Mean Ratings Emotional	Animal
Aboard	0.60	0.00
Canopy	1.13	0.00
Define	0.73	0.00
Duplex	0.67	0.00
Glance	0.53	0.00
Incline	0.53	0.00
Obtain	0.40	0.00
Prefer	0.80	0.00
Shade	0.60	0.00
Adult	1.33	1.93
Bagpipe	1.33	0.00
Pearl	1.47	0.73
Subway	1.87	0.00
Honey	1.93	0.53
Rumble	1.60	0.00
Glove	1.00	0.00
Relate	0.27	0.27
Shawl	0.73	0.60
Grand Means	0.98 (SD = .50)	0.23 (SD = .49)

Set 2

Word	Mean Ratings Emotion	Animal
Amplify	0.93	0.00
Carpet	0.73	0.00
Delay	0.60	0.00
Expend	0.87	0.00
Gate	0.47	0.00
Limit	0.73	0.00
Outset	0.40	0.00
Profile	0.20	0.00
Patrol	1.07	0.00
Crack	1.53	0.00
Anthem	1.73	0.00
Reality	1.73	0.13
Swung	0.60	0.00
Muscle	1.67	0.87
Bucket	0.60	0.00
Salad	1.47	0.13
Easy	1.47	0.00
Invent	1.00	0.00
Grand Means	0.99 (SD = .50)	0.06 (SD = .21)

Appendix C-4 Continued: Neutral Word Sets

Set 3	Mean Ratings	
Word	Emotion	Animal
Await	0.27	0.00
Click	0.53	0.00
Dense	0.67	0.13
Faucet	0.33	0.00
Glue	0.40	0.00
Mustard	0.87	0.00
Passage	0.53	0.00
Quart	0.40	0.00
Shovel	0.73	0.00
Baker	1.47	1.27
Comet	1.87	0.00
Saddle	1.33	0.80
Wound	2.40	0.13
Patio	1.53	0.00
Seeing	1.47	0.40
Grape	0.87	0.13
Clerk	0.67	0.53
Plume	0.20	0.27
Grand Means	0.92 (SD = .62)	0.20 (SD = .35)

Set 4	Mean Ratings	
Word	Emotion	Animal
Birch	0.80	0.00
Clipper	0.13	0.00
Dilute	0.53	0.00
Flare	0.87	0.00
Hidden	0.53	0.00
Note	0.40	0.00
Pitch	0.80	0.00
Rental	0.67	0.00
Smooth	0.73	0.00
Critic	2.07	0.87
Golden	2.07	0.00
Season	1.47	0.00
Pepper	1.67	0.00
Statue	1.47	0.33
Butler	0.40	1.33
Jersey	0.87	1.00
Split	1.13	0.00
Cereal	1.07	0.13
Grand Means	0.98 (SD = .56)	0.20 (SD = .41)

Appendix C-4 Continued: Neutral Word Sets

Set 5	Mean Rating	
Word	Emotion	Animal
Blend	0.67	0.00
Closed	0.60	0.00
Divert	0.67	0.00
Folder	0.13	0.00
Hood	0.60	0.00
Nudge	0.33	0.00
Plate	0.20	0.00
Request	0.47	0.00
Slant	0.13	0.00
Pioneer	1.53	0.93
Mirror	1.53	0.00
Shop	1.80	0.00
Cradle	1.87	0.20
Radio	1.80	0.00
Sugar	1.93	0.13
Carrot	0.80	0.33
Junior	0.93	0.47
Suburb	1.07	0.00
Grand Means	0.95 (SD = .64)	0.11 (SD = .24)

Set 6	Mean Rating	
Word	Emotion	Animal
Behold	0.80	0.40
Butter	1.13	0.47
Convey	0.33	0.00
Doorway	0.73	0.00
Eyebrow	0.47	0.33
Import	0.93	0.00
Optical	0.27	0.00
Plain	0.07	0.00
Scrub	0.40	0.00
Spread	0.33	0.00
Sailor	1.13	1.33
Nickel	1.47	0.00
Skirt	1.53	0.20
Cottage	2.33	0.20
Copper	0.87	0.00
March	1.13	0.13
Smell	2.20	0.40
Verse	0.73	0.00
Grand Means	0.94 (SD = .63)	0.19 (SD = .33)

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