Dissociating the Neural Correlates of Item and Context Memory: An ERP Study of Face Recognition

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Abstract We investigated the neural correlates of item and context retrieval using event-related potentials (ERPS). Particpants studied unfamiliar faces with happy or neutral expressions, and at test, they decided whether test faces were studied in the same or in a different expression, or were new. The parietal ERP effect, which is hypothesized to indirectly reflect medial-temporal lobe (MTL) function, was sensitive to item retrieval, whereas the frontal ERP effect, which is thought to reflect prefrontal cortex (PFC) function, was sensitive to context retrieval. Converging with lesion, functional neuroimaging (PET and fMRI), and ERP evidence, these results support the notion that item retrieval is primarily associated with MTL function whereas context retrieval is primarily associated by PFC function.

Résumé Nous avons examiné les corrélats neuronaux du recouvrement des items et du contexte à l'aide de potentiels évoqués. Les participants ont mémorisé des visages non familiers qui affichaient des expressions joyeuses ou neutres; lors de la reconnaissance, ils devaient décider si les visages présentés affichaient la même expression ou non, ou encore s'ils étaient nouveaux. Le potentiel évoqué pariétal, que l'on suppose refléter indirectement la fonction du lobe médio-temporal, était sensible au recouvrement des items, tandis que le frontal, qui refléterait la fonction du cortex préfrontal, l'était au recouvrement du contexte. Ces résultats, qui vont dans le même sens que les informations découlant d'études sur les lésions cérébrales, de la neuro-imagerie fonctionnelle (PET et IRMF) et des potentiels évoqués, appuient l'idée selon laquelle le recouvrement des items est principalement associé à la fonction du lobe médio-temporal, alors que le recouvrement du contexte l'est à celle du cortex préfrontal.

Remembering personally experienced past events, or episodic memory retrieval, involves both item and context retrieval. Item retrieval refers to remembering *what* events happened, and context retrieval, to remembering *when* (temporal-order memory), *where* (spatial memory) or *how* (source memory) they happened. The distinction between item and context retrieval is important because lesion, functional neuroimaging, and electrophysiological evidence suggests that these two components of episodic retrieval involve different neural mechanisms. In the present study, we investigated the neural correlates of item and context retrieval using event-related potentials.

Lesion evidence has associated item retrieval with the medial-temporal lobe, and context retrieval with the prefrontal cortex. In a classic study by Corsi and Milner (cited by Milner, 1971), patients with MTL lesions were impaired in item retrieval (recognition test) but not in context retrieval (temporal-order test) whereas patients with PFC lesions were impaired in context but not in item retrieval. Although this double dissociation may not be generalizable to other forms of item and context memory, numerous studies with human (e.g., Janowsky, Shimamura, & Squire, 1989; Shimamura, Janowsky, & Squire, 1990) and nonhuman primates (e.g., Petrides, 1991) have found that PFC lesions produce greater deficits in context retrieval than in item retrieval.

Functional neuroimaging evidence is also consistent with the idea that item retrieval is primarily associated with MTL function, and context retrieval, with PFC function. A positron emission tomography (PET) study found that MTL was more activated for item retrieval than for context retrieval, whereas PFC was more activated for context than for item retrieval (Cabeza et al., 1997). This double dissociation was significant when differences in task difficulty were statistically removed, and when item and context conditions with similar levels of performance were compared. Greater PFC activity for context than for item retrieval was also found in several functional magnetic resonance imaging (fMRI) studies (e.g., Eyler Zorilla, Aguirre, Zarahn, Cannon, & D'Esposito, 1996; Nolde, Johnson, & D'Esposito, 1998).

Moreover, a recent PET study dissociated item and context memory as a function of aging. Compared to younger adults, older adults showed weaker PFC activity during context memory, but similar MTL activity during item memory (Cabeza et al., 2000). This result is consistent with evidence that age-related memory deficits are more pronounced for context than for item retrieval (Spencer & Raz, 1995) and that age-related atrophy is more pronounced in PFC than in MTL regions (Raz et al., 1997).

Electrophysiological evidence concerning the neural correlates of item and context memory has been provided by ERPS studies of word recognition (for a review, see Allan, Wilding, & Rugg, 1998). Compared with ERPS for correctly rejected new words (*correct rejections or CRS*), ERPS for correctly recognized studied words (*hits*) have been associated with two positive-going effects: the *parietal effect,* which is maximal over parietal electrodes between 400-800 ms, and the *frontal effect,* which is maximal over frontal electrodes between 700-1,200 ms. The parietal effect is assumed to reflect MTL activity indirectly through its interactions with cortical areas, and the frontal effect is assumed to reflect PFC activity (Allan et al., 1998). Thus, on the basis of lesion (Milner, 1971) and functional neuroimaging (Cabeza et al., 1997) evidence, one would expect the frontal effect to be primarily sensitive to context retrieval, and the parietal effect, to item retrieval. ERP data tend to support these predictions.

In the ERP study by Wilding and Rugg (1996; see also Wilding, Doyle, & Rugg, 1995), participants heard words in either a male or a female voice. At test, they read words and decided if the words were old or new, and in the case of words classified as old, if they were heard at study in a female or a male voice. This method allows for a distinction between trials associated with correct item and context decisions (*hit-hits*), and trials associated with correct item but incorrect context decisions (*hit-misses*). Although both parietal and frontal effects were larger for hit-hits than for hit-misses, the effect was more prominent in the frontal effect, particularly in the right hemisphere. Moreover, Senkfor and Van Petten (1998) found that the parietal effect was similar for a recognition test (old vs. new) and for a source test (same voice vs. different voice vs. new), whereas the frontal effect occurred only for the source task.

There are at least two unresolved issues concerning ERPS for item and context memory. First, it is unknown if the sensitivity of the frontal effect to context retrieval found in word recognition studies can be generalized to nonverbal stimuli. Although frontal effects have been found for nonverbal stimuli such as pictures of common objects (Schloerscheidt & Rugg, 1997) and unfamiliar faces (Graham & Cabeza, 2001), these studies did not include context retrieval conditions. Faces are suitable stimuli for the study of context retrieval because when humans remember faces, we extract and retrieve identity information (who the person is) and we also extract and retrieve contextual information, or episodic detail, such as facial expression. Therefore, the retrieval of facial expression is analogous to context retrieval seen with stimuli such as words. If the modulatory influence of context retrieval on the frontal effect reflects general context retrieval operations, then it should occur not only for verbal but also for nonverbal stimuli, such as faces.

Second, it is unclear if the parietal effect is actually insensitive to context retrieval. The assumption that the parietal effect reflects primarily MTL-mediated item retrieval implies that it should not be sensitive to variations in context retrieval, which supposedly depends on PFC function. Yet, the parietal effect has shown significant hit-hit vs. hit-miss differences in a few word recognition studies (e.g., Wilding, 1999; Wilding & Rugg, 1996). One possible explanation is that these differences reflect an enhancing effect of context retrieval on item retrieval. It is reasonable to expect that recovering context information (i.e., where, when, and how it happened) facilitates the recovery of item information (i.e., what happened). This effect may be more likely in the case of familiar stimuli such as common words, because they are associated with many different contexts outside the experiment. Hence, deciding whether or not they occurred during the experiment can be facilitated by the recovery of specific details of the experimental context (e.g., speakers' voice). In contrast, stimuli that are first encountered during the experiment are more likely to become uniquely associated with the experimental context, and to be retrieved independently of context information recovery. If this idea is correct, then novel stimuli such as unfamiliar faces should yield a parietal effect that is insensitive to context retrieval.

The goal of the present study was to investigate the foregoing issues. Participants studied unfamiliar faces in happy or neutral expressions, and at test, they were presented studied faces in the same or different expression intermixed with nonstudied faces, and for each face, they decided if it was studied in the same expression, studied in a different expression, or nonstudied. Thus, even if face identify and face expression were simultaneously encoded during study, the test allowed us to differentiate *hit/hits*, where both the face and the facial expression were remembered, from *hit/misses*, where the identity was correctly remembered but facial expression was not.

We expected three main results. First, we expected that, as in the case of the frontal effect for words (Wilding & Rugg, 1996), the frontal effect for faces would be larger for hit-hits than for hit-misses. If the modulatory influence of context retrieval on the frontal effect reflects general retrieval operations, then it should occur not only for verbal but also for nonverbal stimuli such as faces. Second, we expected that the parietal effect for faces would be similar for hit-hits and hit-misses. If the contribution of context retrieval to item retrieval is reduced in the case of novel stimuli, then the parietal effect for unfamiliar faces should be relatively insensitive to context retrieval. Finally, we expected that the previous two results would yield a dissociation between frontal and parietal effects: The frontal effect would be sensitive to context retrieval whereas the parietal effect would be sensitive to item retrieval. Such a dissociation would support the notion that the parietal effect is an index item retrieval associated with MTL function, and the frontal effect is an index of context retrieval associated with PFC function, converging with lesion (Milner, 1971) and functional neuroimaging (Cabeza et al., 1997, 2000) evidence.

Method

PARTICIPANTS

Seventeen female undergraduate students participated in the study for course credit. All participants were right-handed and had normal or corrected-to-normal vision.

MATERIALS

The stimuli consisted of 240 black-and-white photos of unfamiliar male and female faces (120 happy, 120 neutral), taken from the Purdue University, the University of Stirling, and the University of Northern British Columbia face databases. Stimulus size was 3.5 by 2.7 inches. The stimuli were coded using the Facial Action Coding System (Ekman & Friesen, 1978) to ensure that neutral faces did not show any extraneous muscle displacement, and that happy faces fulfilled objective criteria for the existence of a smile (Ekman & Friesen, 1975).

PROCEDURE

In each of four blocks, participants studied 20 happy and 20 neutral faces in random order, and then they performed a recognition test that included: (1) 20 studied faces with the same expression as in the study phase (10 happy, 10 neutral); (2) 20 studied faces with a different facial expression than in the study phase (10 happy, 10 neutral); and (3) 20 new faces (10 happy, 10 neutral). The assignment of faces to the four blocks was counterbalanced across participants. Study and test trials consisted of five events: a fixation for 500 ms, a photo of a face for 400 ms, a fixation for 1,600 ms, a response selection screen until a response was made, and a blank screen for 1,000 ms. The fixation was a 3.5 by 2.7 inch gray rectangle. The response selection screen prompted participants to make a decision. At study, participants made a happy/neutral decision by pressing keys with different hands, and also tried to remember the faces and their facial expressions for a subsequent memory test. At test, they made three choice recognition decisions: (a) studied with same expression, (b) studied with different expression, or (c) new. Responses (a) and (b) were assigned to one hand, and response (c) to the other hand. Left/right hand use was counterbalanced across participants at both study and test.

ERP METHODS

EEG was collected from 32 silver/silver chloride electrodes embedded in an electrode cap. Recording locations were based on a variation of the 10/20 international electrode placement system (Jasper, 1956). Sites included frontopolar (FPI, FP2), frontal (F7, F3, FZ, F4, F8), frontocentral (FC3, FZ, FC4), central (C3, CZ, C4), centroparietal (CP3, CPZ, CP4), parietal (P3, PZ, P4), frontotemporal (FT7, FT8), temporal (T7, T8), temporoparietal (TP7, TP8), and occipital (O1, OZ, O2) electrodes. Linked mastoids served as a reference. Horizontal eye movements were monitored with bipolar electrodes on the outer canthus of each eye, and vertical movements were monitored from electrodes placed above and below the left eye. EEG and EOG were recorded with a sampling rate of 500 samples/second for an epoch of 1,700 ms, starting 100 ms prior to the onset of a face. Electrode channels were amplified with a filter bandwidth of 0.03-50 Hz. Trials with values above 100 ΩV or below -100 ΩV, possibly due to blinks or eye movement artifacts, were excluded from the analyses. To ensure an adequate signal to noise ratio in the ERPs, participants who had less than 16 artifact-free trials per item category were replaced.

Results

BEHAVIOURAL DATA

At study, the proportion of faces correctly classified as happy or neutral (.97) was very high, suggesting that participants could easily distinguish between the two expressions. At test, the proportion of "studied" responses (studied-same plus studied-different) was significantly higher, $t(16) = 12.6$, $p < .001$ for studied faces (.76) than for new faces (.36). Among studied faces correctly recognized as studied, the proportion of faces whose expression was correctly classified as "same" or "different" (.69) was reliably greater, $t(16) = 12.0$, $p < .001$ than the proportion of faces whose

ERP's of contextual during face recognition

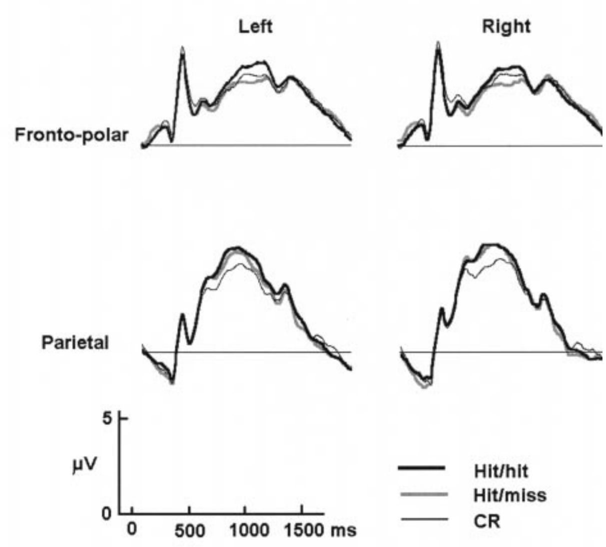

Figure 1. Average voltage values (ΩV) obtained during recognition of happy and neutral faces at parietal and frontal electrodes on both hemispheres.

ERP's of contextual retrieval during face recognition

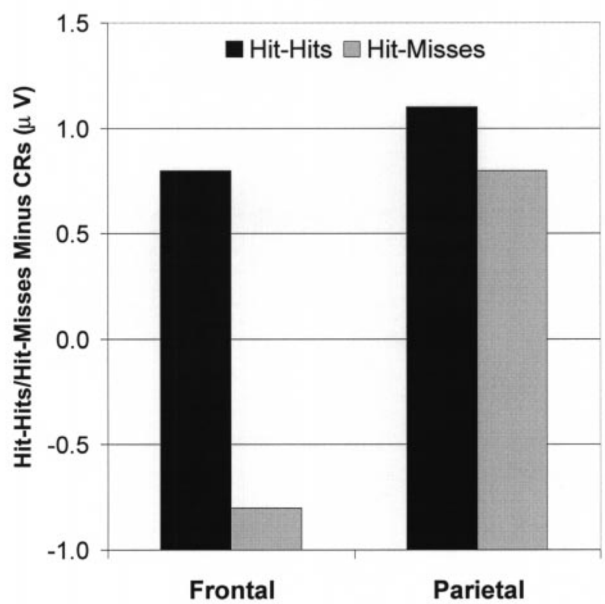

Figure 2. Mean difference amplitudes for hit-hits (hit-hits minus CRS) and for hit-misses (hit-misses minus CRS) obtained at frontal and parietal electrodes (ΩV), collapsed across epochs and hemispheres.

expression was misclassified (.31). Thus, there was a good level of accuracy for both item and context memory retrieval.

ERP DATA

ERPS for correctly recognized test faces were averaged according to three categories. (1) *Hits-hits*: studied faces correctly recognized as studied and correctly classified as same or different expression (i.e., items associated with both successful item retrieval and successful context retrieval). (2) *Hit-misses*: studied faces correctly recognized as studied but incorrectly classified as same or different (i.e., items associated with successful item retrieval but unsuccessful context retrieval). (3) *Correct Rejections* (CRS): new faces correctly classified as new (i.e., items associated with neither item retrieval nor context retrieval).

The ERP results for electrodes of interest (parietal and frontal) are shown in Figure 1. Consistent with previous research, the parietal effect was maximal around 500-800 ms, and the frontal effect around 700-900 ms. To investigate both effects using contiguous epochs, we measured parietal ERPS from 550 ms to 750 ms, and frontal ERPS from 750 ms to 900 ms. Differences in ERP amplitude were analyzed using repeated-measures ANOVAS corrected for inhomogeneity of covariance (Geisser-Greenhouse), and t tests corrected for multiple comparisons (Bonferroni). The statistical measures reported correspond to raw ERP data, but all analyses were confirmed using normalized data (McCarthy & Wood, 1985).

Our first prediction was that the frontal effect for unfamiliar faces would be sensitive to successful contextual retrieval. To test this prediction, we conducted a 3 (item type: hit-hit vs. hit-miss vs. CR) x 2 (hemisphere: left vs. right) ANOVA on frontal ERPS. The analysis yielded a significant main effect of item type, $F(1.6, 26.1) = 11.0$, $p < .001$ but no reliable effect of hemisphere, $F(1, 16) = 1.5$, $p > .05$, or item type x hemisphere interactions ($F < 1$). Pairwise comparisons indicated that ERPS for hit-hits (4.9 µV) were reliably more positive than those for hit-misses, 3.4 µV; $t(16) = 5.1$, $p < .001$ and CRS, 4.2 µV; $t(16) = 2.8$, $p < .015$, with no difference between hit-misses and CRS, $t(16) = -1.9$, $p > .05$. Thus, confirming our first prediction, the frontal effect was larger for hit-hits than for hit-misses

Our second prediction was that the parietal effect for unfamiliar faces would not be sensitive to contextual retrieval. To test this prediction, we conducted a 3 (item type: hit-hit vs. hit-miss vs. CR) x 2 (hemisphere: left vs. right) ANOVA on parietal ERPS. This analysis yielded a significant main effect of item type, $F(1.6, 25.7) =$

9.5, $p < 0.002$, but no reliable effect of laterality ($F < 1$), or item type x hemisphere interactions ($F < 1$). Pairwise comparisons indicated that ERPs for hit-hits were reliably more positive than ERPs for CRs, 4.4 vs. 3.3 μV; $t(16) = 4.6$, $p < .001$ and hit-misses were also more positive than CRs, 4.1 vs. 3.3 μV; $t(16) = 2.7$, $p < .015$, but there was no difference between hit-hits and hit-misses, $t(16) = 1.2$, $p > .05$. Therefore, confirming our second prediction, the parietal effect was similar for hit-hits and hit-misses.

Finally, our third prediction was that the frontal effect would be sensitive to context retrieval but that the parietal effect would be sensitive only to item retrieval. To test this prediction, we subtracted CRs from hit-hits and hit-misses (see Figure 2) and conducted a 2 (item type: hit-hits vs. hit-misses) x 2 (region: frontal vs. parietal) ANOVA, collapsing over hemispheres. Confirming our third prediction, this analysis yielded a significant item type x region interaction, $F(1,16) = 11.0$, $p < .01$. This interaction can be seen in Figure 3 where mean amplitude differences for hit-hits (hit-hits minus CRs) are larger than those for hit-misses (hit-misses minus CRs) at frontal sites, whereas amplitude differences at parietal sites are equivalent in magnitude. The two scalp distributions were also directly contrasted in a 2 (distribution: frontal vs. parietal) x 3 (item type: hit-hits vs. hit-misses vs. CRs) x 2 (hemisphere: right vs. left) ANOVA in order to demonstrate that the effects did come from different generators. This analysis gave rise to a significant item type x distribution interaction, $F(1.6, 24.9) = 9.4$, $p = .002$. This result confirmed the results of earlier analyses, which found that the parietal effect was sensitive to item retrieval, being similar for hit-hits and hit-misses but smaller for CRs, while the frontal effect was sensitive only to context retrieval with hit-hits larger than hit-misses and CRs.

Discussion

The study provided three main results. First, there was a dissociation between the frontal effect, which was sensitive to context retrieval, and the parietal effect, which was sensitive only to item retrieval. This result is consistent with the results from lesion and functional neuroimaging research and supports the idea that context retrieval is associated with PFC activity, and item retrieval with MTL function. Second, the frontal effect for unfamiliar faces was greater for hit-hits than hit-misses. This finding supports the generalizability of the modulatory influence of context retrieval on the frontal effect previously found in word recognition studies. Finally, the parietal effect for unfamiliar faces was similar for hit-hits and hit-misses. This finding supports the idea that the sensitivity of the parietal effect to context retrieval in word recognition studies reflected an influence of context retrieval on item retrieval that is attenuated when using novel stimuli. Below, we discuss the three results, and consider other related issues.

DISSOCIATION BETWEEN FRONTAL AND PARIETAL EFFECTS

The main finding of the present study was a clear dissociation between the influences of context and item retrieval on frontal and parietal effects: The frontal effect was sensitive to context retrieval, whereas the parietal effect was sensitive to item but not to context retrieval. This dissociation is consistent with lesion (e.g., Milner, 1972) and functional neuroimaging evidence (Cabeza et al., 1997, 2000), and supports the idea that context memory is primarily dependent on PFC function, whereas item retrieval is primarily dependent on MTL function.

This idea is central to Moscovitch's (1992, 1994) component process model of memory. According to this model, episodic memory is mediated by two different systems: an associative MTL system and a strategic PFC system. The associative system automatically encodes information that has been consciously apprehended, and it automatically retrieves it whenever an appropriate cue is presented. This system cannot distinguish veridical from false memories, organize the retrieval output, or guide a retrieval search. These "intelligent" functions are provided by the strategic PFC system. This view predicts that age effects should be more pronounced on episodic memory tests that are more dependent on the strategic system, such as context memory, than on tasks that rely primarily on the associative system, such as recognition. As mentioned previously, a recent PET study found age-related decreases in PFC activation during context retrieval together with age-invariant MTL activity during item retrieval (Cabeza et al., 2000).

Instead of a dissociation between item and context retrieval, the present results could also be described as a dissociation between familiarity and recollection (e.g., Atkinson & Juola, 1974; Mandler, 1980). Familiarity refers to the feeling – sometimes very strong – that an item or event occurred in the past, even though no other related contextual information can be retrieved. Recollection, in contrast, refers to the retrieval of specific information about the event, such as its spatiotemporal context or other associated information. Thus, familiarity would involve item retrieval without context retrieval, whereas recollection would involve both item and context retrieval. This does not imply that familiarity and recollection involve a similar level of item retrieval. As mentioned in the introduction, recovering contextual information may facilitate the recovery of item information, and hence, recollection is likely to involve a higher level of item retrieval than familiarity. This would explain why functional neuroimaging studies have found activation differences between recollection and familiarity (e.g., remember/know paradigm) not only in PFC (e.g., Henson et al., 1999), but also in MTL (Elridge et al., 2000).

However, it could be argued that the hit-hit/hit-miss differences found in the present study do not reflect differences between item and context retrieval, or between familiarity and recollection, but rather priming effects. Since, at test, half of the faces were presented in the same expression and half in a different expression, it is possible that the former generated more perceptual priming than the latter. Yet, it is unlikely such priming effects could account for hit-hit/hit-miss differences. First, hit-hit items included faces both in the same and in different expressions, and this applies also to hit-miss items. Thus, if priming effects occurred, they affected both hit-hit and hit-miss items. Second, in ERP studies, priming effects have not been associated with the parietal or the frontal effect but with a different electrophysiological marker (Rugg et al., 1998). Finally, hit-hit/hit-miss ERP differences have been found in conditions in which perceptual priming was attenuated or eliminated by a study-test modality shift (Wilding & Rugg, 1996).

FRONTAL EFFECT

The present study provided the first evidence that the modulatory influence of context retrieval on the frontal effect previously found for words (Senkfor & Van Petten, 1998; Wilding & Rugg, 1996) can be also found for faces. The fact that this modulatory influence can be found when stimuli are verbal and familiar, as well as when they are nonverbal and novel stimuli, and when context information refers to voice quality as well as when it refers to facial expressions, suggest that this influence reflects general context retrieval operations.

The present results are also relevant to the issue of whether the frontal ERP effect reflects *success* in retrieving context information (Wilding & Rugg, 1996) or only the *attempt* to retrieve this information regardless of the outcome of the search (Senkfor & Van Petten, 1998). In Wilding and Rugg's (1996) study, the frontal effect was significantly larger for hit-hits than for hit-misses (Experiment 2), whereas in Senkfor and Van Petten's (1998) study, it was larger in a context retrieval task than in an item retrieval task, but did not show reliable hit-hit/hit-miss differences. Thus, Wilding and Rugg's results are consistent with the retrieval success hypothesis, whereas Senkfor and Van Petten's results are consistent with the retrieval attempt hypothesis. The present results favour the success hypothesis because the frontal effect showed clear hit-hit/hit-miss differences.

It is important to note some differences between the frontal effect in the present study and in word recognition studies. First, there is a difference in the duration of the frontal effect. Whereas in Wilding and Rugg's studies (Wilding & Rugg, 1996; Wilding et al., 1995), the frontal effect extended beyond 1,400 ms, in the present study, it disappeared at about 900 ms. This inconsistency may reflect differences between processing words vs. faces, between retrieving voices vs. expressions, or it may reflect a difference between the double two-choice response (old/new followed by male/female) used in Wilding and Rugg's studies versus the single three-choice response (same/different/new) used in the present study. However, Senkfor and Van Petten (1998) used a single three-choice response and found a frontal effect lasting at least 1,200 ms.

Additionally, whereas in Wilding and Rugg's (1996) study hit-misses showed a frontal effect (i.e., they were more positive than CRS), in the present study they were nonsignificantly different from CRS, and even showed a trend to be *less* positive than CRS. This trend is similar to that found in Wilding (1999). The lack of a significant difference between hit-misses and CRS actually fits very well with the assumption that the frontal effects reflect successful context retrieval because both hit-miss and CR events occur in the absence of context retrieval. What is unclear is why other studies found a frontal effect for hit-misses (Wilding & Rugg, 1996; Wilding et al., 1995). We do not have a good explanation of the trend of hit-misses to be less positive than CRS in our study, but as noted above, this difference was not reliable.

PARIETAL EFFECT

The parietal effect was similar for hit-hits and hit-misses. This implies that the parietal effect was insensitive to context retrieval and supports the idea that the parietal effect is an index of MTL-mediated item retrieval. This finding is counter to those found in word recognition studies, which have reported parietal effects that are sensitive to the retrieval of context (Wilding, 1999; Wilding & Rugg, 1996). As mentioned in the introduction, one explanation for the inconsistency of the parietal effect for context memory may be due to an enhancement of item retrieval, which is facilitated by successful context retrieval.

This enhancement may be sensitive to the nature of the stimuli used in an experiment, being more likely with highly familiar stimuli, such as words, which are encountered in many extra-experimental contexts. Therefore, the decision about whether or not a word occurred during an experiment (item memory) may be aided by the retrieval of contextual information. In contrast, the stimuli used in this experiment were faces that were unfamiliar to the participants and therefore were not associated with extra-experimental contexts. Because the faces were first encountered during the experiment, item retrieval would be less likely to be improved by context retrieval and more likely to occur independently. However, it is possible that the finding of similar parietal effects for hit-hit and hit-miss items is not related to the use of novel stimuli but to the use of faces. Further research about this issue is warranted.

The finding that the parietal effect was similar for hit-hit and hit-miss items does not imply that MTL is not involved in context memory. First, the parietal effect is a very indirect measure of MTL function, and the lack of hit-hit/hit-miss differences on this effect may simply reflect a lack of sensitivity. Second, we investigated a particular form of context retrieval (i.e., retrieval of face expression during face recognition), and the results may not generalize to other forms of context memory. For example, there is a considerable amount of evidence that certain MTL components and their associated structures play an important role in spatial memory (for a review, see Aggleton & Brown, 1999). Finally, the present results apply only to *retrieval*, and do not provide information concerning the role of MTL during the *encoding* of context information.

It is important to note that the magnitude of the parietal effect was somewhat smaller than the one typically found in ERP studies of word recognition (e.g., Allan et al., 1998). Given the high false alarm rate obtained in the study, it is possible that guessing was a factor in the attenuated magnitude of the parietal effect. However, although small, the parietal effect was remarkably consistent across participants.

Conclusions

The present study dissociated the neural correlates of item and context memory. The ERP parietal effect was sensitive to item retrieval, whereas the frontal effect was sensitive to context retrieval. These results are consistent with lesion and functional neuroimaging evidence associating item retrieval primarily with MTL function and context retrieval primarily with PFC function.

We are grateful to Annette Colangelo and Eileen Noel for their technical assistance, and to two anonymous reviewers for useful comments. This research was supported from grants from the National Sciences and Engineering Research Council of Canada and the Alberta Heritage Foundation for Medical Research to RC.

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