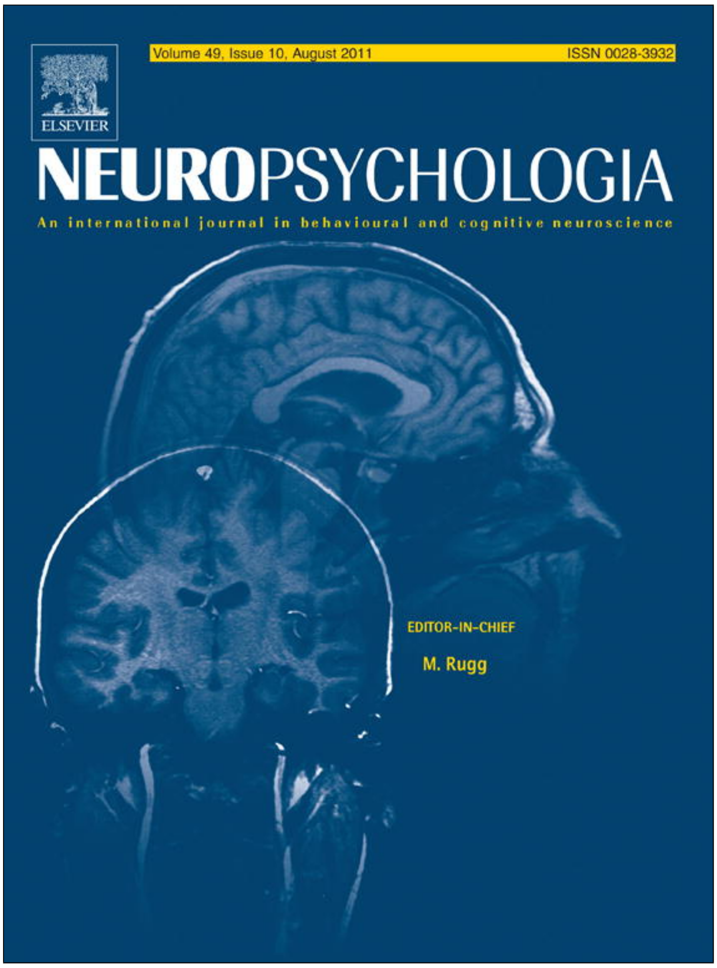
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Strategic retrieval in a reality monitoring task

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ABSTRACT

Strategic recollection refers to control processes that allow the retrieval of information that is relevant for a specific situation. These processes can be studied in memory exclusion tasks, which require the retrieval of particular kinds of episodic information. In the current study, we investigated strategic recollection in reality monitoring by event-related potentials (ERPs). Participants studied object words, followed by a picture of the denoted object (perceive condition) or followed by the instruction to imagine such a picture (imagine condition). At test, subjects had to identify words of one study condition and to reject words of the second study condition together with newly presented items. Data analysis showed that object names were better identified when items of the perceive condition were targeted. In this test condition, a left parietal old/new effect (the ERP correlate of recollection) was observed only in response to targets. In contrast, both targets and nontargets elicited this old/new effect when items of the imagine condition were targeted. The magnitude of the left parietal old/new effect to nontargets in this condition (but no other left parietal old/new effect) correlated positively with the discrimination indices of both test conditions. In addition, ERPs to targets and nontargets differed at right frontal electrode sites at longer latencies (1500–1800 ms), with more positive ERPs for targets. Findings indicate that subjects retrieved nontarget information in the more difficult task condition, while they relied on target information alone in the less difficult task. This kind of strategic retrieval was not mirrored in other old/new effects. The correlation between the left parietal old/new effect for nontargets in the imagined item target condition and the discrimination indices of both conditions may indicate that the ease of nontarget retrieval, rather than the difficulty of target retrieval, increases the likelihood that nontarget information is actually retrieved.

1. Introduction

Episodic memory mediates the remembering of personally experienced events (Tulving, 1972). It can be explicitly stated and is characterized by retrieval of contextual information, like time, place, emotion and other details. Consequently, disturbances of episodic memory are not necessarily characterized by a complete failure to remember, but sometimes also by insufficient or incorrect retrieval of contextual information.

It is assumed that control processes guide episodic retrieval and assure the selective recovery of contextual information. Thus, the control processes allow the retrieval of information that is relevant for a specific situation and for specific task demands at hand. Such control processes have been conceptualized as strategic retrieval (Moscovitch, 1992; Herron & Wilding, 2005). The usage of strategic retrieval can be studied in memory exclusion tasks (Jacoby, 1991), because these tasks require the differentiation of source information during retrieval. In this kind of experiment, items are studied in two (or more) different conditions: Word items might, for example, be presented in a male or female voice. At test, only words of one study condition are defined as targets, while other items (studied and unstudied) have to be rejected as nontargets. In order to successfully identify test items as targets, item information has to be recollected together with source information.

While this is necessarily true for target items, a different strategy might be used for rejecting nontargets, as first outlined by Herron and Rugg (2003b). Rather than using a 'recall-to-reject' strategy (Clark, 1992), test responses could be based just on target information. Subjects might endorse an item as a target if its recognition is accompanied by the reactivation of matching source-specifying information and reject all other items for which such information is not available (Herron & Rugg, 2003b). Such a strategy would thus make the retrieval of nontarget source information redundant. In support of this view, an absence of left parietal old/new effects in

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response to nontargets has been reported in some event-related potential (ERP) studies using memory exclusion tasks (e.g. Dywan, Segalowitz, Webster, Hendry, & Harding, 2001).

This left parietal old/new effect, starting about 500 ms after the presentation of a test item, is commonly associated with recollection. It has been found to be larger after deep encoding tasks than after shallow encoding tasks (Rugg, Mark, Walla, Schloerscheidt, Birch, & Allan, 1998). Furthermore, it is larger for correct than incorrect source judgments (e.g. Wilding, 2000), and larger for remember than for know responses (e.g. Düzel, Yonelinas, Mangun, Heinze, & Tulving, 1997). The lack of a left parietal effect to nontargets in memory exclusion tasks (e.g. Dywan et al., 2001) indicates that recollection may, in some instances, be confined to targets.

In order to further clarify the role of nontarget retrieval in exclusion tasks, Herron and Rugg (2003b) conducted a study, which varied the levels of processing of targets at study while keeping the encoding of nontargets constant. The authors predicted that with less reliable target information the recollection of nontargets should become more likely as it promotes overall task performance. Indeed, a left parietal old/new effect to targets, but not to nontargets, was observed when targets were deeply encoded and target discrimination was easy. In contrast, an additional left parietal old/new effect to nontargets was observed when targets were encoded shallowly and target discrimination was difficult. Thus, the finding was in line with the assumption that recollection of nontarget information occurs when target information alone is not sufficiently diagnostic to make a target/nontarget differentiation (see also Herron & Rugg, 2003a).

In a follow-up study, it was shown that target accuracy is not the only determinant of nontarget retrieval (Herron & Wilding, 2005). In this study, targets were encoded in a pleasantness judgment task and nontargets in an animacy judgment task. Target accuracy was modulated by the time delay between the encoding of targets and the retrieval phase. Unlike the previous study, left parietal old/new effects for nontargets were absent in both conditions. The authors concluded that the distinctiveness of the contexts associated with targets and nontargets might be another, possibly more important factor for strategic retrieval than task difficulty; that is, if the two kinds of information are easily distinguishable (as in the case of two different encoding tasks), it is less likely that nontarget information is recollected.

In the current study, we were interested in the mechanisms of strategic retrieval in reality monitoring tasks. This specific form of source monitoring requires the differentiation of memories of self-generated information vs. externally perceived information (Johnson, Hashtroudi, & Lindsay, 1993). Within the source memory framework, it is proposed that the origin of information is not tagged and read out of memory (Johnson et al., 1993). Rather, the attribution to an external or internal source is the result of a decision process that works on the basis of qualitative characteristics of the memory trace. Thus, perceptual richness of memories might be diagnostic for external sources, whereas records of cognitive operations might be diagnostic for internally generated memories (Johnson et al., 1993; Johnson, Foley, Suengas, & Raye, 1988).

Failures of reality monitoring are observable in clinical conditions, such as in schizophrenia (e.g. Vinogradov, Luks, Schulman, & Simpson, 2008) or Alzheimer's disease (e.g. Mammarella & Fairfield, 2006). They may, however, also be observed in everyday situations of healthy subjects: In the morning, we might find the computer still in an operating mode although we were fully convinced that we switched it off the day before. Routines like switching off a computer are characterized by repetition and, as a consequence, by low levels of action monitoring. Under such conditions, a planned (imagined) action might easily be remembered as performed and perceived. Yet, little is known about the mechanisms we use for differentiating between self-generated and externally perceived information during retrieval, given the high perceptual similarity of these memories.

To our knowledge, the issue of strategic retrieval in reality monitoring has not been addressed in previous ERP studies. Instead, these studies addressed retrieval differences between internally generated and externally presented source information and between such reality monitoring and mere old-new recognition (Wilding & Rugg, 1997; Johansson, Stenberg, Lindgren, & Rosén, 2002; Leynes, Cairns, & Crawford, 2005). In the study of Johansson et al. (2002), items were encoded in an imagine condition and in a perceive condition that had to be differentiated at test. In the absence of a behavioral difference, old/new effects between 600 and 900 ms were larger for imagined items. There were, however, no topographical differences between old/new effects for the two kinds of items, suggesting that similar processes support the retrieval of imagined and perceived source information. Likewise, Wilding and Rugg (1997) reported larger, but topographically similar, left parietal old/new effects (500–800 ms) for words that were spoken as compared to heard at study. Frontal ERPs in this latency range (500–800 ms) also differed between the two kinds of studied items, while a later occurring right frontal old/new effect (1100–1400 ms) did not vary between them. In the study by Leynes et al. (2005), subjects had to differentiate at test between words they had either heard or generated during study. In this study, generated items were better remembered than perceived items. Old/new effects were again larger for generated words but only at an early latency range (400–600 ms). Taken together, previous ERP findings on reality monitoring suggest quantitative rather than qualitative differences between the retrieval of self-generated and externally perceived information, with old/new effects being larger for self-generated information, together with a better retrieval performance for these items in some (but not all) studies.

The current study aimed to investigate strategic retrieval in reality monitoring. Participants studied object names in two conditions: in one condition subjects perceived a picture of a named object (perceive condition), in a second condition subjects had to mentally create such a picture (imagine condition). In the test phase, subjects had to identify studied object names of one condition and to reject object names of the second condition together with new (unstudied) object names. The prime interest of the study was the modulation of the left parietal old/new effect to nontargets, depending upon the kind of targeted information.

In addition, the impact of target status and study condition on other ERP correlates of retrieval processing was analyzed. For the early midfrontal old/new effect (400–600 ms), the putative ERP correlate of familiarity, no impact of target status was expected since this effect is related to a fast acting and acontextual form of memory (Rugg & Curran, 2007). In contrast, two ERP effects indexing post-retrieval processes could potentially be influenced by strategic retrieval, namely the late posterior negativity (LPN) and the late right frontal old/new effect.

A LPN usually occurs at the time of response onset, i.e. in source monitoring tasks at a time point when the source specifying information has been retrieved. It has been assumed that the LPN reflects processes that act to reconstruct the prior study episode when task-relevant attribute conjunctions are not readily recovered or need continued evaluation (Johansson & Mecklinger, 2003). According to this view, one might expect a larger LPN when recollection of target information is difficult (and nontarget information is retrieved). However, previous studies have not observed a systematic variation of the LPN with strategic retrieval (Evans, Wilding, Hibbs, & Herron, 2010; Herron & Wilding, 2005; Wilding, Fraser, & Herron, 2005). Instead, rather than being tied to strategic retrieval, the LPN has been suggested to co-vary with the amount of contex-

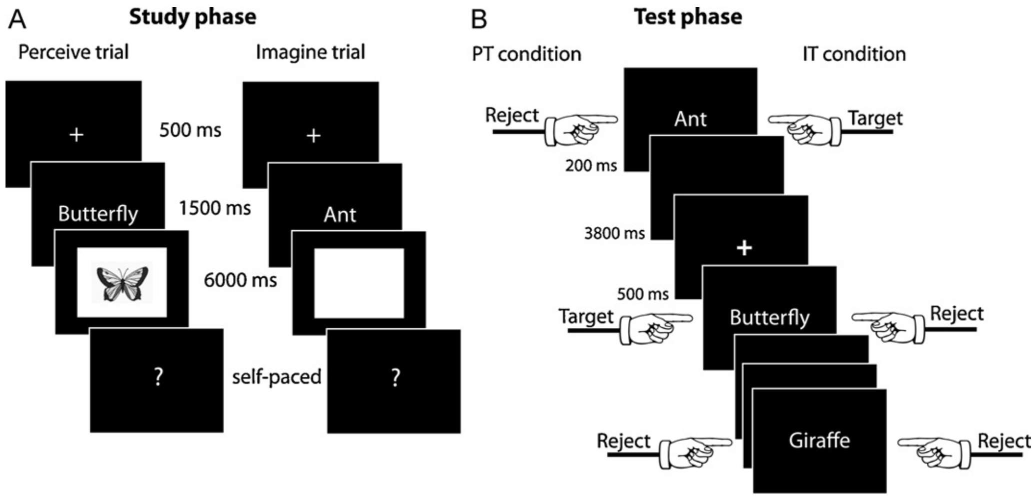

Fig. 1. Schematic illustration of the experimental set-up. (A) During the study phase, object names were presented followed by a picture of the denoted object (perceive condition) or by an empty frame (imagine condition). In the latter condition, subjects were requested to imagine a picture of the named object and project this image onto the white frame. The two trial types were mixed during the study block. (B) During the test phase, old items of one study condition were defined as targets. Old items of the second study condition had to be rejected together with newly presented items. The two retrieval conditions were labeled as perceived item target condition (PT condition) and imagined item target condition (IT condition). Please note that the designation of old items as targets and nontargets were balanced across subjects. Within a subject, any old item was presented once and, thus, was either a target or nontarget. The target category switched after half of the test trials.

tual information associated with the different sources (Johansson & Mecklinger, 2003; Mecklinger, Johansson, Parra, & Hanslmayr, 2007). Therefore, we expected a larger LPN for imagined items, since these items are associated with a greater amount of retrievable contextual details than perceived items (namely visual object information *plus* information about the cognitive operations of generating them).

The functional role of the late right frontal old/new effect is not yet fully understood. An influential view holds that the effect reflects post-retrieval monitoring processes engaged after recollection of source information (Allan, Wilding, & Rugg, 1998; Cruse & Wilding, 2009) and that the recollection of source information (as reflected in the left parietal old/new effect) is a necessary, but not a sufficient prerequisite for post-retrieval monitoring processes (Wilding & Rugg, 1997). According to this view, the right frontal effect does not necessarily show a co-variation with the left parietal old/new effect. Nevertheless, in two studies on strategic retrieval the right frontal and the left parietal old/new effects did show a similar pattern (Herron & Rugg, 2003b; Herron & Wilding, 2005). The idea that the frontal old/new effect reflects post-retrieval monitoring processes, however, is not undisputed. Although monitoring demands should vary with the difficulty of retrieving source information, the right frontal effect has been shown to be unaffected by task difficulty (Kuo & Van Petten, 2008). Furthermore, some studies report a right frontal effect in absence of a left parietal effect (e.g. ERPs to nontargets in Dzulkifli & Wilding, 2005). Given these ambiguous findings, we made no specific prediction about how the right frontal old/new effect would be affected by the present experimental conditions.

2. Methods

2.1. Participants

Thirty-two volunteers (16 female), ranging in age from 18 to 32 years (mean age 22.9 years) took part in the experiment. All participants were students at Saarland University and reported to be of good health with no history of neurological illness. Only German native speakers were included. All subjects were right handed and had normal or corrected-to-normal vision. All subjects were informed about the procedure of the experiment and gave written consent for participation. Participation was compensated with 8 €/h.

2.2. Experimental procedure

Subjects were tested in a memory exclusion task, with an experimental set-up adopted from Johansson et al. (2002). During study, object names were presented on a trial-by-trial basis in one of two conditions: Object names were either followed by a picture of the denoted object or followed by the instruction to mentally create such a picture (Fig. 1A). All trials started with the presentation of a fixation cross for 500 ms and of an object name for 1500 ms. In the perceive condition, a colored picture of the object with a white rectangle as background was shown for 6000 ms. During this period, subjects had to examine the picture. In the imagine condition, the word was followed by a white rectangle without a picture for the same duration. In this condition, subjects were requested to imagine a drawing of the named object and to project this mental image onto the white rectangle on the screen. At the end of each trial, subjects had to rate whether the graphic distinctiveness of the perceived or imagined item was good, fair or bad. Subjects rated the items by button press on the numerical part of a computer keyboard (with 1 for good, 2 for fair, and 3 for bad graphic distinctiveness), as soon as a question mark appeared on the screen. The response initiated the next study trial. No more than three trials of the same condition occurred in succession.

During test, subjects had to identify word items of one study condition and to reject items of the second condition together with new words not presented at study (Fig. 1B). Trials started with a fixation cross, lasting for 100 ms and followed by an empty screen for 400 ms. Object names were presented for 200 ms. Items of each study condition were used as targets at test (perceived item target condition and imagined item target condition). The target category switched after half of the trials, with the order of target conditions balanced across subjects. Subjects were instructed to respond as fast and accurately as possible. A maximal response time of 3800 ms was allowed. Subjects responded with their index fingers, using the letters “C” and “M” on a computer keyboard. The assignment of the keys to the response category (targets vs. nontargets & new) was counterbalanced across subjects.

In addition to the behavioral task, subjects filled out the Vividness of Visual Imagery Questionnaire (VVIQ, Marks, 1973) in order to test whether memory performance was modulated by the visual image vividness. The VVIQ was conducted during the preparation for the EEG recording. VVIQ performance had no impact on memory performance, as previously reported in Rosburg, Mecklinger, & Johansson (2011).

2.3. Stimuli

Words were presented in German on a 17 in. monitor in white 18 pt Courier New font on a black background. Only words with a length between 3 and 10 characters and a frequency ranging from 1 to 475 occurrences per million were included. Word frequency was checked with the Celex linguistic database (Baayen et al., 1993). Ambiguous object names were not included.

The pictures used in this study consisted of colored painted object drawings (Rossion & Pourtois, 2004), originating from the picture set of Snodgrass and Vanderwart (1980). The pictures were framed by a white rectangle with a consistent size of 75% of the screen height and width. Similarly, the pictures displayed within the frame were 75% of the dimensional size of the frame. In the imagine condition, the same frame was presented without a picture. Word and picture displays were centered in the middle of the computer screen, with subjects sitting 60–80 cm in front of it.

The study list consisted in total of 184 object names and pictures. Items were grouped into two lists of 92 items. The word length and word frequency of the two lists did not differ between lists and their halves. The assignment of the two lists to the study conditions was counterbalanced across subjects. In each of the test conditions, there were 46 targets to be identified, and 46 old items of the second study condition (in the following labelled as nontargets), together with 46 new items that had to be rejected.

2.4. EEG data

EEG was recorded continuously from 59 silver/silverchloride EEG electrodes, embedded in elastic caps (Easycap, Herrsching, Germany). Electrode locations in these caps are based on an extended 10–20 system (10–10 system). In addition, electroocular activity was recorded by two pairs of electrodes placed at the outer canthi and below and above the right eye. For recording, data were referenced to the left mastoid. Data were sampled with 500 Hz and filtered online from 0.016 Hz (time constant 10 s) to 250 Hz. Electrode impedances were kept below 5 kΩ.

Offline, data were digitally filtered from 0.1 Hz to 40 Hz (48 dB), with an additional notch filter in order to suppress line activity, and re-referenced to linked mastoids. The impact of eye artifacts on EEG activity was eliminated by a correction algorithm based on independent component analysis (ICA) and implemented in the used analysis tool (VisionAnalyzer 2.01, Gilching, Germany). After down-sampling to 200 Hz, data were exported to EEGLab (Swartz Center for Computational Neuroscience, University of California San Diego, USA). Here, a second ICA was run in order to eliminate the impact of muscular, electrocardiographic, and technical artifacts. Data were segmented into epochs of 3000 ms duration, including a 500 ms pre-stimulus baseline. Data were baseline corrected and screened for artifacts that remained undetected by the ICA procedure. Trials with EEG activity exceeding ±100 μV, exhibiting abnormal trends, or being abnormally distributed (±5 SD from the mean) were excluded.

Average ERPs were calculated for identified targets (T), as well as for correctly rejected nontargets (NT) and correctly rejected new items (NEW), separately for each of the two test conditions. The two test conditions are abbreviated as IT (imagined item target condition) and PT (perceived item target condition). In addition, ERPs to missed targets were calculated (T_missed). Due to the low number of trials with missed targets, data of the two test conditions were collapsed. Individual ERPs to missed targets were only considered for the analysis if a minimum of 8 trials was at hand. For all other ERPs, there was a minimum of 16 trials. A detailed analysis of retrieval orientation effects (Rugg & Wilding, 2000), contrasting the ERPs to new item between the two conditions, is reported elsewhere (Rosburg et al., 2011).

2.5. Data analysis

Behavioral data: The discrimination index (Pr) was quantified as the difference between the hit rate (P_hits) and the false alarm rate to nontargets (P_FA), for each target condition separately (Snodgrass & Corwin, 1988). (E.g. $Pr_{PT} = P\_hits_{PT} - P\_FA_{PT}$, where PT refers to the test condition). Behavioral responses were compared between the two conditions by means of paired *t*-tests and repeated measure analysis of variance (ANVOA).

ERP data: In an initial analysis, we assessed the time course and topography of old/new effects, by contrasting the ERPs to old items and new items. For this analysis, the mean ERP amplitudes in each target condition were quantified for 100-ms bins from 300 to 2000 ms for targets, nontargets and new items. ERPs were then compared between old and new items by paired t-tests for each of the 58 scalp electrodes. Since this analysis revealed old/new effects that corresponded well to those described in the literature, we do not report it in detail. However, the initial analysis motivated the analysis of an unexpected late left central old/new effect (see below). Furthermore, the results of the paired t-tests are incorporated in all depicted ERP data (Figs. 3–5 and S1–S2). The colored vertical bars at the top and bottom of the ERP graphs indicate 100-ms bins with significant old/new effects (red bars: target old/new effects with $p < 0.05$; blue bars: nontarget old/new effects with $p < 0.05$).

In the principal ERP analysis of the current study, we assessed the differences of old/new effects between conditions and targets/nontargets at representative electrodes. For this analysis, the mean ERP amplitudes between 400–600 ms, 600–900 ms, 900–1200 ms, 1200–1500 ms, and 1500–1800 ms were calculated. These time windows were chosen based on the study of Johansson et al. (2002), but also in accordance with the results obtained by the paired *t*-tests of the initial analysis. ERP data were compared by a repeated measure ANOVA with CONDITION (IT vs. PT) and STIMULUS (T vs. NT vs. NEW) as within-subject factors at single representative electrodes. The electrode selection was based on prior research, again taking the findings of our initial analysis into consideration. If a particular old/new effect was detected at several neighboring electrodes, the electrode in the spatial middle was regarded as representative. For example, the left parietal old/new effect was found to be largest at the electrodes P3, P5, P7, and PO7. Consequently, electrode P5 was selected for the analysis. A similar approach was chosen for the other old/new effects except for the early old/new effect (400–600 ms) that was spatially more widespread compared to the other effects. Here, we decided to analyze the effect at two electrodes (P5 and Cz), with Cz reflecting best its mid-frontal distribution. Note that the findings at the two electrodes were highly similar (Table 1). Differential old/new effects between conditions would be indicated by CONDITION*STIMULUS interactions. When these interactions were significant, the old/new effects were tested within each condition by calculating a repeated measure ANOVA with STIMULUS (T vs. NT vs. NEW) as a within-subject factor.

In order to evaluate the functional significance of the observed old/new effects, the ERPs to missed targets were also analyzed and compared to ERPs to new items by paired *t*-tests. ERPs to identified and missed targets might share some similarities (e.g. correlates of retrieval effort), but by definition ERPs to missed targets cannot reflect successful source recollection. For the analysis of missed targets, ERPs were collapsed across conditions due to the small number of available trials. We focused on those time windows, for which we had revealed old/new effects for correctly identified old items (T and NT).

Finally, Pearson correlation coefficients were calculated between left parietal old/new effects and the Pr values in each condition (Pr_IT and Pr_PT), and their difference Pr_PT–Pr_IT (Pr_diff), in order to assess whether the strategic recollection is associated with the difficulty of target discrimination.

3. Results

3.1. Behavioral data

Behavioral data has been reported before (Rosburg et al., 2011). Target discrimination (Pr) was poorer in the imagined item target (IT) condition as compared to the perceived item target (PT) condition (Pr_IT = 0.65 SD 0.20 vs. Pr_PT = 0.74 SD 0.16, $t_{31} = 4.481$, $p < 0.001$). Detailed inspection showed that the hit rate was lower ($t_{31} = 3.410$, $p = 0.002$) and the false alarm rate was higher ($t_{31} = 2.902$, $p = 0.007$) in the IT condition than in the PT condition.

The test conditions also affected the reaction times (RTs). A repeated-measures ANOVA with STIMULUS (Target, Nontarget, New items) and CONDITION (PT, IT) as factors revealed a significant STIMULUS*CONDITION interaction ($F_{2,62} = 9.281$, $p < 0.001$), indicating that the differences between items varied depending upon the stimulus type. Between conditions, reaction times differed for new items ($t_{31} = 3.365$, $p = 0.002$) and targets ($t_{31} = 4.350$, $p < 0.001$), with slower reaction times in the IT condition (Fig. 2). No difference between conditions was found for reaction times to nontargets ($t_{31} = 1.171$, n.s.). Reaction times were always faster for new items than for both kinds of old items in both conditions (all $t_{31} > 5.695$, $p < 0.001$). In the PT condition, subjects responded faster to targets than to nontargets ($t_{31} = 3.595$, $p = 0.001$), while in the IT condition the corresponding reaction times did not differ ($t_{31} = 1.692$, n.s.). There was no indication of a speed-accuracy trade-off.

3.2. ERP data: old/new effects for targets in each condition

Typical old/new effects were revealed in the experiment when ERPs to old items were compared to ERPs to new items. These effects comprised the early fronto-central old/new effect, the late left parietal old/new effect, the LPN, and the late right frontal effect. With the exception of the LPN, all old/new effects were characterized by more positive ERP deflections to old items compared to new items. Two additional and unexpected old/new differences were found. First, at left parietal sites, ERPs to old and new items differed at rather early latencies, which might be due to an overlap of the early frontal and an early onsetting left parietal old/new effect. Consequently, in the principal analysis the left parietal effect was also analyzed in the early time window (400–600 ms). Secondly, we observed a late left central old/new effect (900–1500 ms) not described in the literature. Old/new effects are graphically depicted for representative electrodes and as topographic maps in Figs. 3–5 and S1–S3 (Supplementary Data).

Table 1
CONDITION and STIMULUS effects.

Time	Ch.	STIMULUS	CONDITION	STIMULUS × CONDITION	Missed targets
Early fronto-central effect					
400–600 ms	Cz	$F_{2,62} = 11.150$ $P < 0.001$ NEW < T, NT	$F_{1,31} = 1.256$ n.s.	$F_{2,62} = 0.600$ n.s.	$t_{23} = 2.552$ $P = 0.018$ NEW < T_missed
Left parietal effect					
400–600 ms	P5	$F_{2,62} = 27.959$ $P < 0.001$ $\varepsilon = 0.845$ NEW < T, NT	$F_{1,31} = 1.091$ n.s.	$F_{2,62} = 0.824$ n.s.	$t_{23} = 2.954$ $P = 0.007$ NEW < T_missed
600–900 ms	P5	$F_{2,62} = 18.269$ $P < 0.001$ $\varepsilon = 0.800$	$F_{1,31} = 0.360$ n.s.	$F_{2,62} = 3.669$ $P = 0.031$ PT: NEW, NT < T IT: NEW < NT, T	$t_{23} = 0.997$ n.s.
900–1200 ms	P5	$F_{2,62} = 14.824$ $P < 0.001$ $\varepsilon = 0.820$	$F_{1,31} = 0.019$ n.s.	$F_{2,62} = 9.990$ $P < 0.001$ PT: NEW, NT < T IT: NEW < NT, T	$t_{23} = 0.017$ n.s.
LPN					
900–1200 ms	POz	$F_{2,62} = 1.016$ n.s.	$F_{1,31} = 1.452$ n.s.	$F_{2,62} = 10.160$ $P < 0.001$ PT: NT < T, NEW IT: T < NT, NEW	$t_{23} = 2.316$ $P = 0.030$ T_missed < NEW
1200–1500 ms	POz	$F_{2,62} = 5.924$ $P = 0.004$	$F_{1,31} = 0.450$ n.s.	$F_{2,62} = 8.970$ $P < 0.001$ PT: NT < NEW IT: T < NT, NEW	$t_{23} = 2.171$ $P = 0.040$ T_missed < NEW
Late left central effect					
900–1200 ms	C5	$F_{2,62} = 6.221$ $P = 0.002$ NEW < T	$F_{1,31} = 1.005$ n.s.	$F_{2,62} = 2.402$ n.s.	$t_{23} = 2.547$ $P = 0.018$ T_missed < NEW
1200–1500 ms	C5	$F_{2,62} = 7.746$ $P = 0.001$ NEW < T, NT	$F_{1,31} = 4.962$ $P = 0.033$ PT < IT	$F_{2,62} = 0.600$ n.s.	$t_{23} = 0.627$ n.s.
Late right frontal effect					
1200–1500 ms	F6	$F_{2,62} = 8.262$ $P = 0.001$ NEW < T, NT	$F_{1,31} = 0.295$ n.s.	$F_{2,62} = 0.961$ n.s.	$t_{23} = 1.028$ n.s.
1500–1800 ms	F6	$F_{2,62} = 10.767$ $P < 0.001$ NEW, NT < T	$F_{1,31} = 0.241$ n.s.	$F_{2,62} = 0.966$ n.s.	$t_{23} = 0.704$ n.s.

Overview of the ANOVA results: The main effects for CONDITION (IT vs. PT) and STIMULUS (T vs. NT vs. NEW), as well as their interaction are described for the selected time windows (time) and electrodes (Ch.). In the right column, old/new effects for missed targets are listed.

3.3. *ERP data: comparison of old/new effects for targets and nontargets between conditions*

The conducted ANOVA revealed that the early fronto-central old/new effect, the early left parietal old/new effect, and the late left central old/new effect did not differ between conditions and between targets and nontargets. In contrast, differential old/new effects were detected for the left parietal old/new effect, the LPN and for the late right frontal old/new effect. The results of the ANOVA are summarized in Table 1.

An early fronto-central old/new effect was detected in the latency range from 400 to 600 ms. ERPs to old items were more positive than ERPs to new items (Fig. S1). This old/new effect was similar for targets and nontargets and did not differ between conditions (Table 1).

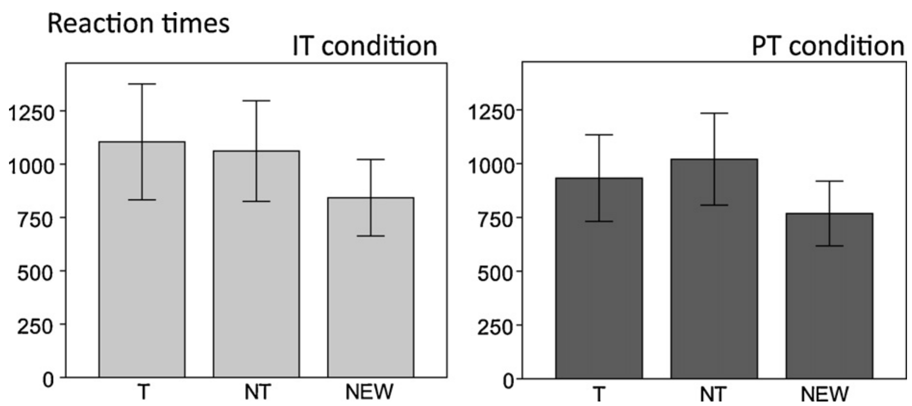

Fig. 2. Mean reaction times (±1SD) for the three kinds of items (targets, nontargets, new) for both conditions separately. In the IT condition, reaction times were significantly slower for targets and new items than in the PT condition.

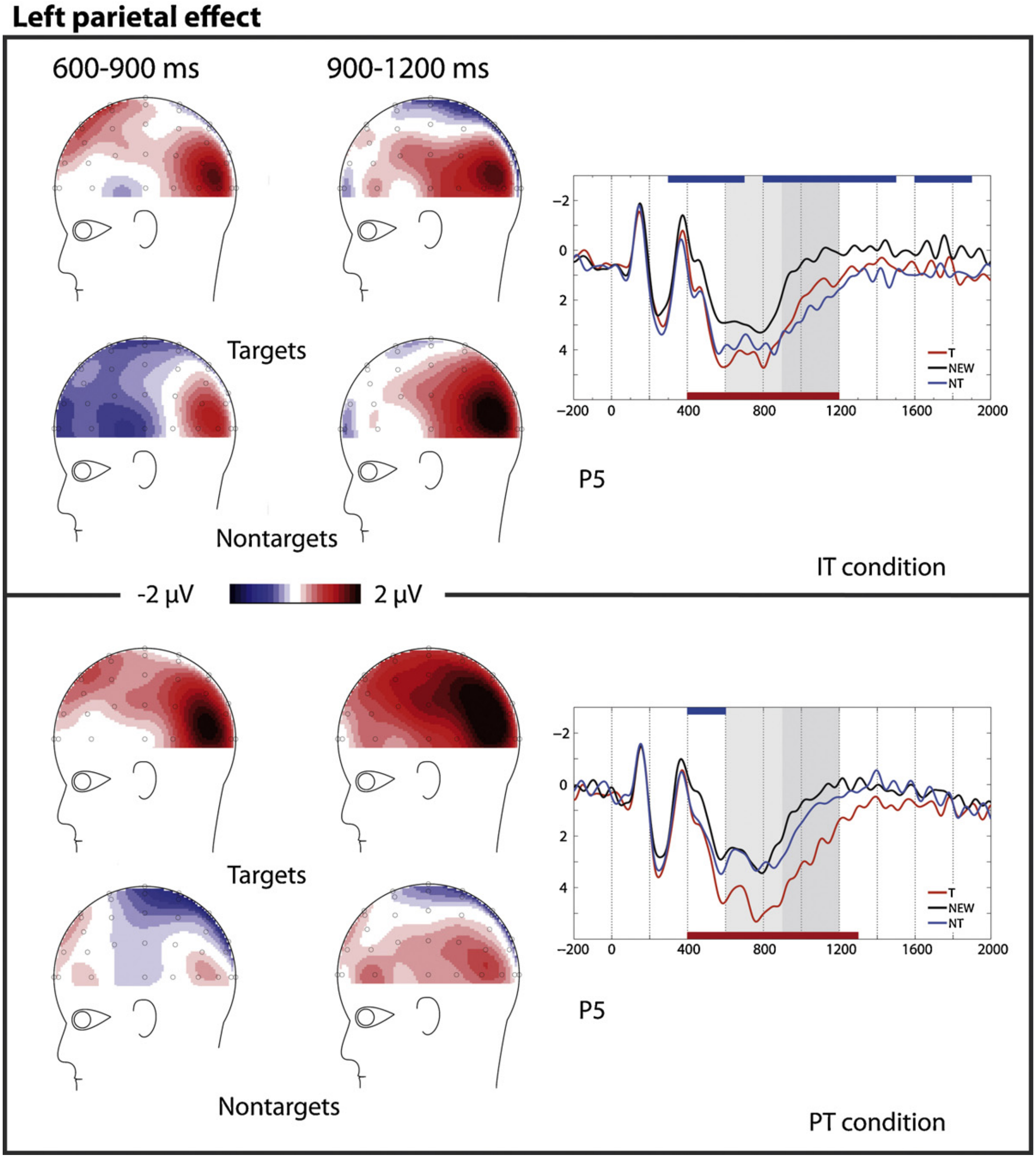

Fig. 3. The left parietal old/new effects for targets and nontargets in the two test conditions, for the 600–900 ms (leftmost) and 900–1200 ms (left next) latency range: Difference maps are displayed from a left-sided perspective in order to highlight the left parietal old/new effect. Amplitude information is color-coded in these maps. On the right, ERPs to targets, nontargets and new items for each condition are shown for the electrode P5 where the left parietal old/new effect was maximal, with data of the IT condition at the top and data of the PT condition at the bottom. ERPs to targets are depicted as red lines, ERPs to nontargets as blue lines, and ERPs to new items as black lines. The two grey shaded areas in the ERP mark the latency ranges, for which difference maps are displayed on the left. The blue and red bars at the frames of the ERP data indicate those 100 ms time bins, for which significant old/new effects were detected by paired *t*-tests ($p < 0.05$; red: target effects; blue: nontargets effects). Left parietal old/new effects were found for nontargets in the IT condition and for targets in both conditions. In contrast, ERPs to nontargets did not differ from ERPs to new items in the PT condition.

A left parietal old/new effect was observed from about 400 ms, with more positive ERPs at left parietal electrode sites to targets. For the early time window from 400 to 600 ms, the effect was similar for targets and nontargets and did not differ between conditions. For each of the two later time windows from 600 to 900 ms and 900 to 1200 ms, a significant STIMULUS*CONDITION interaction was found. A comparison of ERPs to the different kinds of stimuli within each condition revealed that in the PT condition, targets but not nontargets elicited a significant left parietal old/new effect. In contrast, both targets and nontargets elicited old/new effects in the IT condition (Fig. 3, Table 2). A direct comparison of left parietal old/new effects between the two conditions revealed similar old/new effects for targets (600–900 ms: $t_{31} = 1.217$, n.s.; 900–1200 ms: $t_{31} = 1.518$, n.s.), but significantly smaller old/new effects for nontargets in the PT condition than in the IT condition (600–900 ms: $t_{31} = 1.797$, n.s.; 900–1200 ms: $t_{31} = 2.933$, $p = 0.006$).

For the LPN, a significant STIMULUS*CONDITION interaction was detected in both of the analyzed time windows (900–1200 ms and 1200–1500 ms). In the IT condition, a LPN was found only in response to targets. In contrast, only the LPN to nontargets became

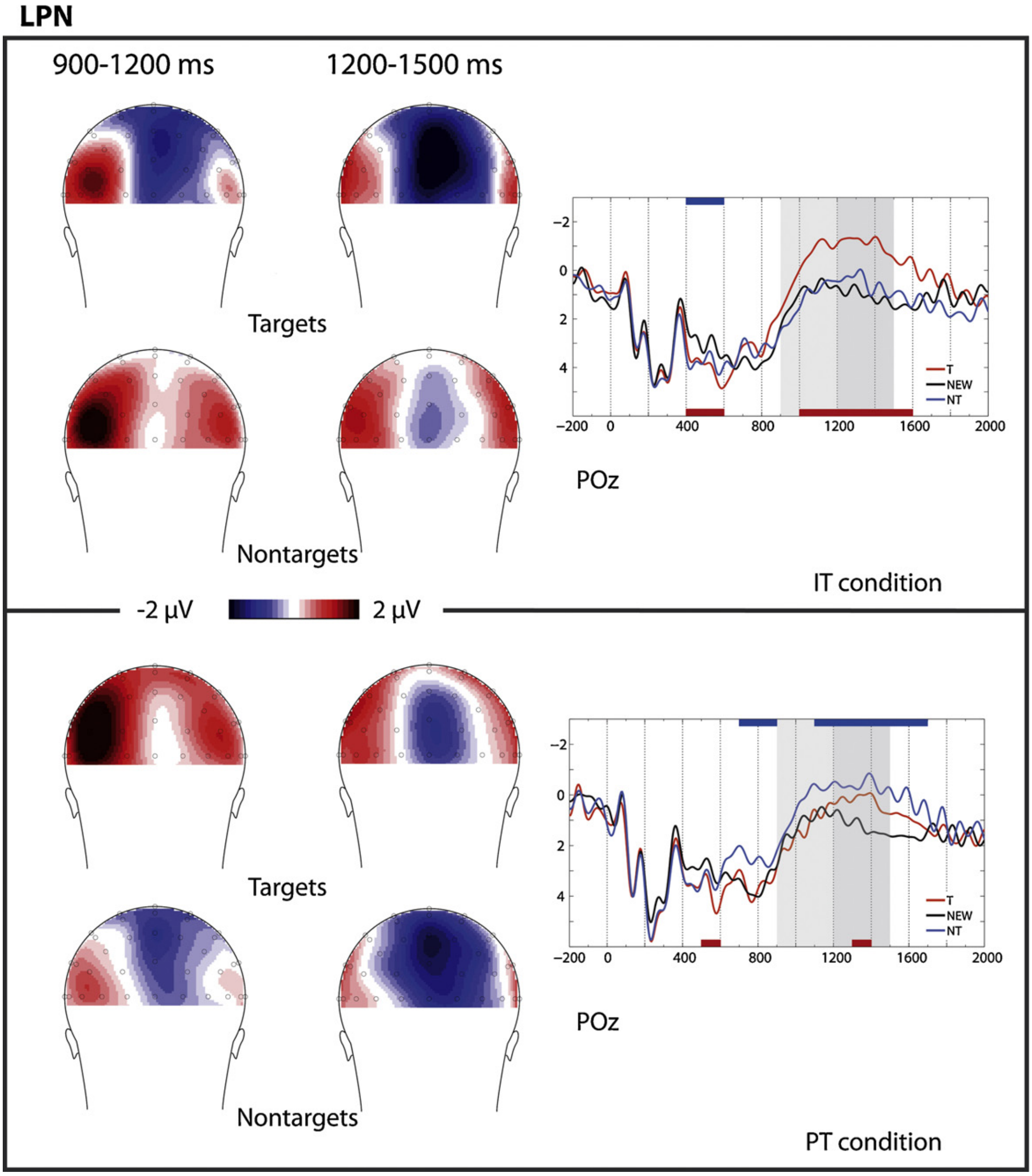

Fig. 4. The LPN old/new effects for targets and nontargets in the two test conditions, for the 900–1200 ms (leftmost) and 1200–1500 ms (left next) latency range: The structure of the figure is the same as in Fig. 3, but difference maps are displayed from the back view in order to highlight the LPN effect. ERPs are shown for the electrode POz where the LPN effect was maximal. In both test conditions, the LPN was larger for items from the imagine condition, as compared to items from the perceive condition.

significant in the PT condition (Fig. 4, Table 2). A direct comparison of old/new effects between the two conditions revealed a larger LPN effect for targets in the IT condition (900–1200 ms: t_{31} = 2.605, p = 0.014; 1200–1500 ms: t_{31} = 1.913, n.s.) and a larger LPN effect for nontargets in the PT condition (900–1200 ms: t_{31} = 1.858, n.s.; 1200–1500 ms: t_{31} = 2.306, p = 0.028).

A late left central and a late right frontal effect were observed for targets and nontargets in both conditions, with no apparent difference between targets and nontargets and between conditions for the 1200–1500 ms time window (Figs. 5 and S2). In the later time window (1500–1800 ms), the right frontal ERPs to targets were larger than the ERPs to nontargets and new items, irrespective of condition (Table 1). Visual inspection suggested that the right frontal old/new effect was larger for nontargets in the imagined item target condition, but this effect could not be statistically substantiated. STIMULUS*CONDITION interactions remained nonsignificant even when the comparison was restricted to nontargets and new items.

3.4. ERP data: old/new effects for missed targets

The analysis was based on data of 24 subjects who had ≥8 artifact-free trials of missed targets. ERPs to missed targets were compared to ERPs to new items. This analysis revealed significant early old/new effects for missed targets (400–600 ms), as well as a significant LPN (Fig. S3). In contrast, a left parietal old/new effect, the late left central and late right frontal old/new effect could not

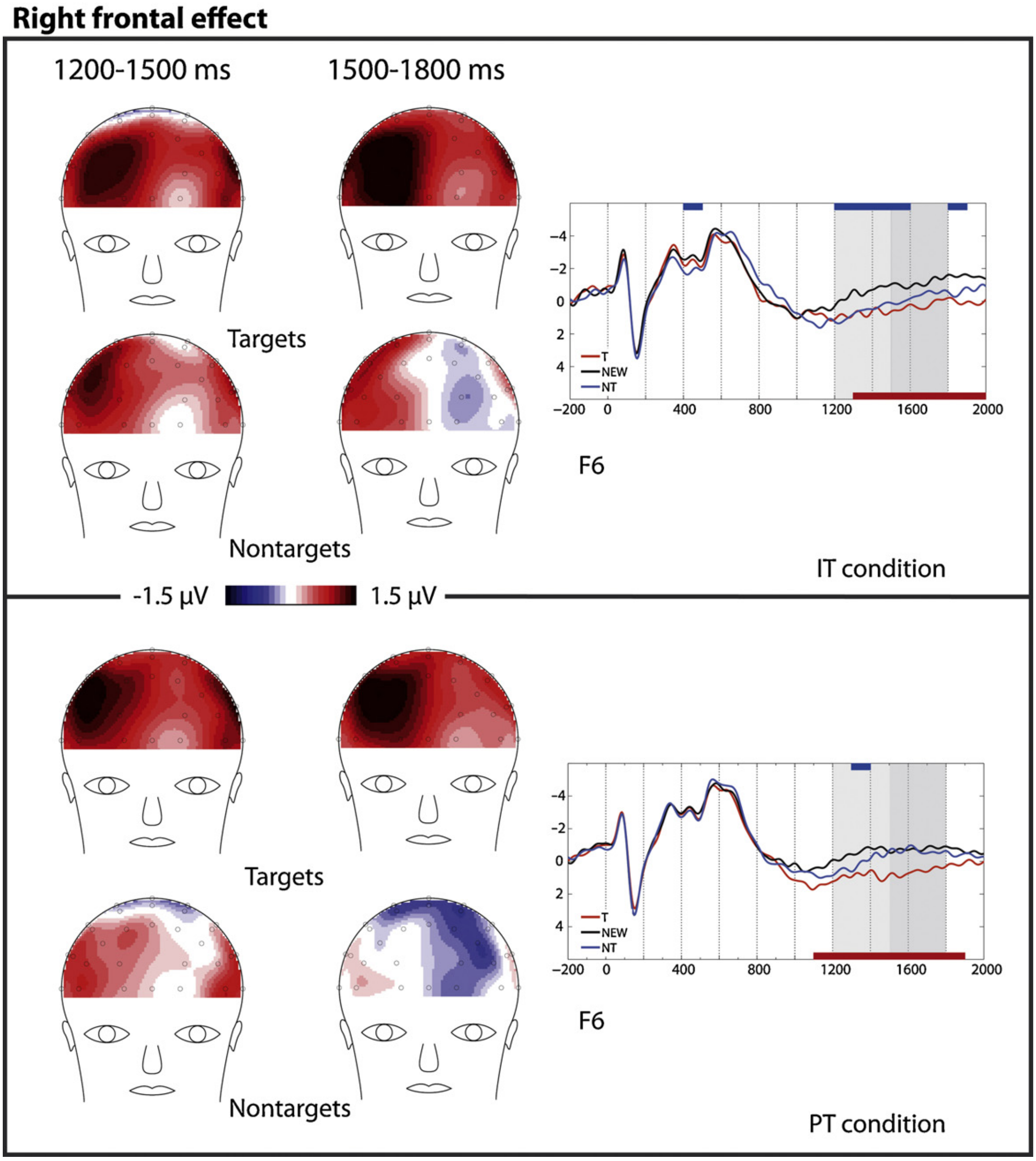

Fig. 5. The right frontal old/new effects for targets and nontargets in the two test conditions from 1200 to 1500 ms and 1500 to 1800 ms. The structure of the figure is the same as in Fig. 3, but difference maps are displayed from the front in order to highlight the late right frontal old/new effect. ERPs are shown for the electrode F6 where this effect was maximal. In earlier latency range, the late right frontal old/new effects had a similar magnitude for targets and nontargets and did not differ between conditions. In the later time window, targets elicited larger old/new effects than nontargets.

be observed (Table 1). Notably, an analysis restricted to subjects with ≥14 artifact-free trials ($n = 17$) revealed highly similar results.

3.5. *ERP data and behavioral data: correlation of left parietal old/new effects with Pr values*

Left parietal old/new effects were quantified as the difference values between old and new items between 600 and 900 ms and between 900 and 1200 ms at electrode P5, for targets and nontargets. Only the old/new effect for nontargets from 600 to 900 ms in the IT condition correlated significantly with discrimination indices. This was positively correlated with both the Pr value of the IT condition ($r = 0.415$, $p = 0.018$) and the Pr value of the PT condition ($r = 0.447$, $p = 0.010$), but not the difference between them (Pr_diff; $r = 0.117$, n.s.).

4. Discussion

The main findings of the current study can be summarized as follows: Object names were better remembered when they had been studied in the perceive condition. In the ERP data, the early familiarity-related old/new effect (400–600 ms) did not differ between the two test conditions. The late left parietal old/new effect (600–900 ms and 900–1200 ms) was found in response to targets in both conditions and to nontargets in the imagined item target condition, but the effect was absent for nontargets in the less difficult perceived item target condition. The LPN was modulated by the study task condition: Items of the imagine condition elicited a larger LPN at test than items of the perceive condition, irrespective of their status as target or nontarget. The late right frontal old/new effect was observed in response to targets and nontargets at early

Table 2
STIMULUS effects in each condition.

		PT	IT
Left parietal effect			
600–900 ms	P5	$F_{2,62}=18.283$ $P<0.001$ NEW < T: $t_{31}=4.891$, $P<0.001$ NEW < NT: $t_{31}=0.628$, n.s. NT < T: $t_{31}=4.951$, $P<0.001$	$F_{2,62}=6.366$ $P=0.003$ NEW < T: $t_{31}=3.077$, $P=0.004$ NEW < NT: $t_{31}=2.899$, $P=0.007$ NT < T: $t_{31}=1.036$, n.s.
900–1200 ms	P5	$F_{2,62}=14.031$ $P<0.001$, $\varepsilon=0.783$ NEW < T: $t_{31}=4.292$, $P<0.001$ NEW < NT: $t_{31}=1.482$, n.s. NT < T: $t_{31}=5.009$, $P<0.001$	$F_{2,62}=12.358$ $P<0.001$ NEW < T: $t_{31}=3.090$, $P=0.004$ NEW < NT: $t_{31}=5.394$, $P<0.001$ NT < T: $t_{31}=1.424$, n.s.
LPN			
900–1200 ms	POz	$F_{2,62}=2.727$ n.s. T < NEW: $t_{31}=0.320$, n.s. NT < NEW: $t_{31}=1.800$, n.s. NT < T: $t_{31}=2.504$, $P=0.018$	$F_{2,62}=5.072$ $P=0.009$ T < NEW: $t_{31}=2.312$, $P=0.028$ NT < NEW $t_{31}=0.500$, n.s. T < NT: $t_{31}=2.875$, $P=0.007$
1200–1500 ms	POz	$F_{2,62}=5.578$ $P=0.006$ T < NEW: $t_{31}=1.866$, n.s. NT < NEW: $t_{31}=3.125$, $P=0.004$ NT < T: $t_{31}=1.542$, n.s.	$F_{2,62}=7.440$, $P=0.003$, $\varepsilon=0.837$ T < NEW: $t_{31}=3.120$, $P=0.004$ NT < NEW: $t_{31}=1.058$, n.s. T < NT: $t_{31}=2.870$, $P=0.007$

The effects of STIMULUS (T vs. NT vs. NEW) in each of the two retrieval conditions: Only time windows with significant CONDITION x STIMULUS interactions in the initial ANOVA (Table 1) are described here.

latencies (1200–1500 ms), while at later latencies (1500–1800 ms) this old/new effect occurred only for target items. A late left central old/new effect did not differ between targets and nontargets. Missed items elicited an early fronto-central old/new effect and a LPN, but no other old/new effects.

4.1. Behavioral effects

The analysis showed that subjects' retrieval accuracy was better when they targeted items of the perceive condition. This was not an expected finding. In a previous ERP study, items of the two conditions were equally well retrieved, both in a source-monitoring task and in a recognition task (Johansson et al., 2002). In the behavioral experiments of Johnson, Kounios, & Reeder (1994), using the response-signal speed-accuracy trade-off procedure, source information of imagined items could be retrieved faster and the source accuracy of imagined items was better than for perceived items. However, in that study, the retrieval performances for imagined and perceived items were similar at long time lags (1500 ms) and when response times were not speeded by the test procedure. In contrast, studies using verbal material showed pronounced retrieval advantages for self-generated material in recognition and reality monitoring tasks (Leynes et al., 2005; Riefer, Chien, & Reimer, 2007; Slamecka & Graf, 1978).

Why is the generation effect for pictorial material sometimes absent (Johansson et al., 2002; Johnson et al., 1994, unspeeded response condition) and in some cases, even reversed, such as in the current study? It is well established that pictures are generally better remembered than words (the so-called picture superiority effect, Paivio, Rogers, & Smythe, 1968). Thus, in the perceive condition, verbal material is encoded together with easy to-remember material (pictures), resulting in strong cue-target associations (McDaniel, Waddill, & Einstein, 1988). When those pictures are self-generated (imagined), there may be no additional gain in the strength of the cue-target associations, presumably due to a ceiling effect. This is underlined by the finding that both imagine and perceive conditions have been shown to allow highly effective encoding of item and source information (Johansson et al., 2002).

Although effective cue-target associations were established in both conditions, one can safely assume that the encoded information differed between them. As outlined, perceptual richness of memories can be regarded as diagnostic for external sources, whereas memories for cognitive operations are diagnostic for internally generated memory contents (Johnson et al., 1988, 1993). This has two major implications for the current study. Firstly, in our study, the perceptual richness of perceived items was presumably a more powerful criterion for target identification than in previous studies (Johansson et al., 2002; Johnson et al., 1994), because we used colored versions of the Snodgrass picture set, which provide more perceptual details than the black-and-white versions used before (Rossion & Pourtois, 2004). Secondly, because we used a blocked test design, retrieval accuracy might have been affected by the homogeneity of source information. For perceived items, the source information was homogeneous (pictorial information, uniform in style). For imagined items, source information might have encompassed pictorial information of the mental images and information on the cognitive operations leading to their creation. The latter kind of information might in itself have been heterogeneous, since the cognitive operations leading to the creation of mental images are not necessarily the same for all trials, also due to the varying difficulty in creating mental images.

Taken together, we propose that the two factors (high vividness of perceived items and the larger homogeneity of source information for perceived items in combination with the blocked test design) favored the retrieval of perceived items and led to better retrieval accuracy for these items.

4.2. Early fronto-central old/new effect

An early familiarity-related old/new effect was observed for targets and nontargets, but the effect did not differ between them. Study condition also had no impact on the magnitude of this old/new effect, either as a condition effect alone or as an interaction with stimulus status. A similar old/new effect for targets and nontargets was expected, since familiarity describes relatively fast acting and acontextual memory processes and consequently should not be influenced by the definition of an old item as target or nontarget (Czernochowski, Mecklinger, Johansson, & Brinkmann, 2005; Mecklinger, 2006; Rugg & Curran, 2007). Familiarity-related differences between heard and spoken words have been described in previous studies (Wilding & Rugg, 1997; Leynes et al., 2005), but not between imagined and perceived items (Johansson et al., 2002). Notably an early old/new effect was also observed for missed items (but no left parietal old/new effect), suggesting that those object labels elicited a sense of familiarity (i.e. of having been experienced during the episode), without remembering the study episode itself. As a consequence, those familiar object names were not correctly identified as targets. A similar finding of an early frontal old/new effect for missed targets in an exclusion task was reported by Bridson, Fraser, Herron, & Wilding (2006). Taken together, the findings on the early familiarity-related old/new effect are in accordance with the literature.

4.3. Late left parietal old/new effect

The late left parietal old/new effect to targets did not differ significantly between the two test conditions. Thus, the current findings do not parallel findings of Johansson et al. (2002), who revealed larger left parietal old/new effects for imagined items than for perceived items. Johansson et al. (2002) referred the larger old/new effect for imagined items to the possibility that imagined items contained a larger amount of potential retrieval cues established during encoding than perceived items, i.e. the generation effect (Slamecka & Graf, 1978). For perceived items of the current study, the amount of potential retrieval cues was presumably larger because of the employment of colored and more detailed object pictures (Rossion & Pourtois, 2004), which in turn might have led to similar left parietal old/new effects for both test conditions.

Our primary interest here, however, was the ERP response to nontargets. The left parietal old/new effect was absent for nontargets in the PT condition, while it was present for nontargets in the IT condition. In the latter condition, the old/new effect had a similar size for targets and nontargets. This finding is in accordance with the hypothesis of Herron and Rugg (2003b) that retrieval of nontarget information takes place when retrieval of target information is difficult and, thus, target information alone is not sufficiently diagnostic for reliable target-nontarget discrimination. The similarity of the two memory traces (both kinds of studied items were associated with similar visual information) alone does not seem to be a sufficient prerequisite for nontarget retrieval, as there was no indication of retrieval of nontarget information when perceived items were targeted. This finding is in line with previous studies, showing that the similarity between target and nontarget information alone does not have a major influence on whether or not nontarget information is retrieved (Wilding et al., 2005; Evans et al., 2010).

Based on the assumption that nontarget retrieval occurs when target retrieval is difficult (Herron & Rugg, 2003b), one might expect that the likelihood of nontarget retrieval increases with increasing task difficulty. Thus, one would expect to observe a *negative* correlation between the discrimination index Pr in the IT condition and the left parietal old/new effect to nontargets in this condition. This was not the case. Instead, positive correlations between the retrieval accuracy in both conditions and the left parietal old/new effect to nontargets in the IT condition were revealed. This could indicate that subjects with good retrieval performance were possibly more efficient in initiating nontarget retrieval in order to pursue the current task goal when retrieval of target information is difficult.

However, the currently observed correlation between the left parietal old/new effect to nontargets and retrieval accuracy in both tasks allows also an alternative explanation. We propose that nontarget retrieval occurs in situations when the retrieval of nontarget information is easier than retrieval of target information, regardless of the difficulty with which target information is retrieved. This view can explain the correlation pattern as follows. We assume that perceived items are retrieved as nontargets because they are better remembered and because they more readily reactivate source-specifying information than imagined items do. The ease with which items from the perceive condition are retrieved is reflected relatively purely in the discrimination index Pr of the PT condition because nontarget information was not retrieved in this condition, as indicated by the ERP data. Thus, we observe a correlation between the discrimination index in the PT condition and the left parietal old/new effect to nontargets in the IT condition. We assume further that the correlation between the left parietal old/new effect to nontargets and the discrimination index in the IT condition is driven by the fact that retrieval of nontarget information allowed a better performance. Subjects could therefore use the readily retrieved nontarget information for rejecting nontargets.

Further studies are warranted to test this new hypothesis that the ease of nontarget retrieval is a major determinant as to whether and to what extent nontarget information is actually retrieved. This hypothesis, however, is also supported by previous findings. Retrieval of nontarget information occurred in the difficult condition of Herron and Rugg (2003a) but not in the easy condition of Herron and Rugg (2003b), although the hit rate for targets in the two conditions (as indicator for retrieval difficulty) was the same. Thus, the comparison across the two studies would suggest that retrieval difficulty for targets alone is not predictive for nontarget retrieval (see also Herron & Wilding, 2005). Instead, we can firmly assume that the retrieval of nontarget information was easier than the retrieval of target information in those study conditions showing nontarget retrieval. In Herron and Rugg (2003a), nontarget retrieval occurred when nontargets had the same format at study and test (words at study and test), while the formats of targets differed between the study and the test phases (pictures at study and words at test), providing a retrieval advantage for nontargets over targets. In Herron and Rugg (2003b), nontarget retrieval occurred when nontarget information was deeply encoded while target information was only shallowly encoded, again providing a retrieval advantage for nontargets compared to targets.

The retrieval of nontarget information in the current and previous studies (Herron & Rugg, 2003a,b) might actually be driven primarily by bottom-up mechanisms, in the sense that subjects do not actively search for source information of nontargets, but that the presentation of nontarget cues reactivates this information (cf. incidental recollection, e.g. Richardson-Klavehn & Gardiner, 1995; Kompus, Eichele, Hugdahl, & Nyberg, 2011). However, this implies that subjects do not need to strategically emphasize picture retrieval because it is easier to remember, but that subjects make use of it because the pictorial information comes effortlessly to mind when the cue is presented. Such bottom-up mechanisms might be complemented by top down mechanisms of strategic retrieval, i.e. the voluntary broadening of the retrieval orientation to target and nontarget information (e.g. initiated by the experienced task difficulty or by the ease of access to nontarget information). A similar distinction between top-down and bottom-up mechanisms of memory retrieval has been made in a recent model on attentional control of episodic memory (Cabeza, 2008; Cabeza, Ciaramelli, Olson, & Moscovitch, 2008). An exact differentiation between bottom-up and top-down mechanisms of nontarget retrieval has yet to be achieved in future studies.

4.4. LPN

We found a larger LPN for items of the imagine condition than for items of the perceive condition, irrespective of which information was targeted. This finding suggests that the LPN was not modulated by strategic retrieval mechanisms, in line with previous ERP studies that also did not find a LPN modulation by strategic retrieval (Herron & Wilding, 2005; Wilding et al., 2005; Evans et al., 2010). The lack of a systematic relationship between strategic retrieval and the LPN indicates that recollection processes as reflected in the left parietal old/new effect have no (or at best very little) predictive value for LPN characteristics. This is also supported by previous findings, showing that the LPN is generated during erroneous source judgments (Friedman, Cycowicz, & Bersick, 2005; Leynes & Phillips, 2008; Mecklinger et al., 2007).

The current observation that missed targets elicited a pronounced LPN corroborate the view that LPN generation is not contingent upon successful retrieval of source specifying information, but that the LPN reflects an attempt to reconstruct the prior study episode when task-relevant attribute conjunctions are not readily recovered or need continued evaluation (Johansson & Mecklinger, 2003). This need might be mediated primarily by task conditions (e.g. Curran, DeBuse, & Leynes, 2007), but might also be influenced by recognition confidence (Ranganath & Paller, 2000; Leynes & Bink, 2002; Herron, 2007; Cruse & Wilding, 2009). Interestingly, in the current study, the LPN to perceived items was absent (when these items were nontargets) or at best marginally significant (when perceived items were targets). This might indicate that perceived information was only minimally re-evaluated, which could be a consequence of relatively effortless retrieval of this kind of information.

However, the need for a continued evaluation cannot be regarded as the only factor influencing the LPN characteristics. Johansson and Mecklinger (2003) argued that the LPN also varies with the amount of contextual information potentially available for the reconstruction of the study episode, because the attempt to reconstruct the prior study episode would include sensory-specific search and the binding of a recognized item to contextual attributes. Support for this view was provided by one study from Mecklinger et al. (2007). The LPN data of the current study might be interpreted in similar terms. Items from both study conditions were associated with visual information, but in the case of imagined items, visual information was complimented by information about the cognitive operations associated with generating these items (Johnson et al., 1993). Furthermore, as outlined in the discussion of the behavioral effects, the source information for imagined items was potentially more heterogeneous than for perceived items. Thus, it appears reasonable to assume that the amount of contextual information potentially available in the test phase was larger for items of the imagine condition and, as consequence, could have resulted in larger LPNs to these items. Yet, the relative contribution of the two sources of variance on the LPN (experienced need for a continued evaluation and the amount of available contextual details) cannot be fully determined on the basis of the current data.

4.5. *Late right frontal old/new effect*

The late right frontal old/new effect did not differ between targets and nontargets in the earlier time window (1200–1500 ms), while in the later time window (1500–1800 ms) the effect was larger for targets than for nontargets, irrespective of the retrieval condition. Thus, not unexpectedly, the pattern observed for the right frontal old/new effect did not concur with the pattern of the left parietal old/new effect. Functional dissociations between the late left parietal and right frontal old/new effects have been reported previously in studies on ageing (Trott, Friedman, Ritter, & Fabiani, 1997) and on the effects of source accuracy (Senkfor & Van Petten, 1998; Van Petten, Senkfor, & Newberg, 2000).

It has been proposed that the late right frontal old/new effect reflects post-retrieval monitoring processes engaged after recollection of source information (Allan et al., 1998). Following this account, recollection of source information (as reflected in the left parietal old/new effect) would be a necessary, but not a sufficient prerequisite for post-retrieval monitoring processes (Wilding & Rugg, 1997). In other words, an absent left parietal old/new effect would be predictive of an absent right frontal old/new effect, but a present left parietal old/new effect would not allow any firm prediction of the right frontal effect. The current findings fit widely with the aforementioned assumption of Wilding and Rugg (1997). The right frontal effect was negligible for nontargets in the PT condition and was absent for missed targets, neither of which elicited significant left parietal old/new effects. Similarly, Herron and Wilding (2005) did not observe a late right frontal old/new effect to nontargets that failed to elicit a left parietal old/new effect.

Following the account of the right frontal old/new effect as a reflection of post-retrieval monitoring processes it is, however, noteworthy that the nontarget effect had a shorter duration than the target effect, even in the IT condition when nontargets elicited a left parietal old/new effect. This observation indicates that subjects processed nontargets and targets differently, and suggests that nontargets underwent less comprehensive post-retrieval monitoring processes than targets. This would be in line with the assumption formulated above that the currently observed nontarget retrieval might have been driven more by bottom-up processes than by top-down processes.

However, the account of the right frontal old/new effect as a reflection of post-retrieval monitoring processes is not undisputed. As already outlined, a right frontal old/new effect in the absence of a left parietal effect has been reported in some studies (ERPs to nontargets in Dzulkifli & Wilding, 2005; ERPs to hits/missed items in Cruse & Wilding, 2009). Furthermore, previous findings on the impact of recognition confidence on the right frontal old/new effect are difficult to reconcile with the retrieval monitoring account, as decisions with high recognition confidence were reported to elicit larger (and not smaller) frontal effects than decisions with low recognition confidence (Woodruff, Hayama, & Rugg, 2006; Cruse & Wilding, 2009).

A second view on the right frontal effect claims that the effect reflects generic decision processes rather than a product of an episodic retrieval attempt (Dobbins & Han, 2006; Hayama, Johnson, & Rugg, 2008). The current findings do not support this notion because it would be difficult to reconcile this position with an absent frontal effect for missed targets or a difference in effect amplitude between targets and nontargets. However, it should be noted that the two major concepts of the right frontal effect (post-retrieval monitoring processes and generic decision processes) are not mutually exclusive.

Taken together, in the current experiment, the right frontal old/new effect did not follow the pattern found for the left parietal old/new effect and is therefore regarded as not to be influenced by strategic retrieval. However, the shorter duration of the right frontal effect to nontargets than to targets indicates that the post-retrieval processes reflected in this old/new effect were generally less engaged for nontargets.

4.6. *Late left central old/new effect*

The left parietal old/new effect was followed by a late left central old/new effect that was not modulated by target status, thus did not show an indication of strategic retrieval. To our knowledge, this kind of old/new effect has not been described in the literature before. Given this and the lack of modulation by target status and by condition, we can only speculate about the functional significance of this old/new effect. Its topography and timing might imply motor or reafference functions. However, response buttons were balanced across the experiment, which should control against the lateralization of response-related functions. Furthermore, the effect was also seen for contrasts between new items and nontargets that always required a response with the same finger. Instead, the left-lateralization might indicate the involvement of language functions, as e.g. in form of an inner verbalization of the response decisions for old items.

5. Conclusion

Our findings indicate that subjects retrieved nontarget information in the more difficult task condition, while they relied on target retrieval alone in the less difficult task. This kind of strategic retrieval was not mirrored in other ERP old/new effects, such as the LPN. The correlation between the left parietal old/new effect for nontargets in the IT condition and the discrimination indices of both conditions possibly indicates that the ease of nontarget retrieval (and less the difficulty of target retrieval) increases the likelihood that nontarget information is actually retrieved.

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Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at doi:10.1016/j.neuropsychologia.2011.07.002.

References

Allan, K., Wilding, E. L., & Rugg, M. D. (1998). Electrophysiological evidence for dissociable processes contributing to recollection. *Acta Psychologica*, *98*(2–3), 231–252.

Baayen, H., Piepenbrock, R., Rijn, H. van. (1993). *The CELEX lexical database (CD-ROM)*. University of Pennsylvania, Linguistic Data Consortium.

Bridson, N. C., Fraser, C. S., Herron, J. E., & Wilding, E. L. (2006). Electrophysiological correlates of familiarity in recognition memory and exclusion tasks. *Brain Research*, *1114*(1), 149–160.

Cabeza, R. (2008). Role of parietal regions in episodic memory retrieval: The dual attentional processes hypothesis. *Neuropsychologia*, *46*(7), 1813–1827.

Cabeza, R., Ciaramelli, E., Olson, I. R., & Moscovitch, M. (2008). The parietal cortex and episodic memory: An attentional account. *Nature Reviews. Neuroscience*, *9*(8), 613–625.

Clark, S. E. (1992). Word frequency effects in associative and item recognition. *Memory and Cognition*, *20*(3), 231–243.

Cruse, D., & Wilding, E. L. (2009). Prefrontal cortex contributions to episodic retrieval monitoring and evaluation. *Neuropsychologia*, *47*(13), 2779–2789.

Curran, T., DeBuse, C., & Leynes, P. A. (2007). Conflict and criterion setting in recognition memory. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, *33*(1), 2–17.

Czernochowski, D., Mecklinger, A., Johansson, M., & Brinkmann, M. (2005). Age-related differences in familiarity and recollection: ERP evidence from a recognition memory study in children and young adults. *Cognitive, Affective and Behavioral Neuroscience*, *5*(4), 417–433.

Dobbins, I. G., & Han, S. (2006). Isolating rule-versus evidence-based prefrontal activity during episodic and lexical discrimination: A functional magnetic resonance imaging investigation of detection theory distinctions. *Cerebral Cortex*, *16*(11), 1614–1622.

Dywan, J., Segalowitz, S. J., Webster, L., Hendry, K., & Harding, J. (2001). Event-related potential evidence for age-related differences in attentional allocation during a source monitoring task. *Developmental Neuropsychology*, *19*(1), 99–120.

Dzulkifli, M. A., & Wilding, E. L. (2005). Electrophysiological indices of strategic episodic retrieval processing. *Neuropsychologia*, *43*(8), 1152–1162.

Düzel, E., Yonelinas, A. P., Mangun, G. R., Heinze, H. J., & Tulving, E. (1997). Event-related brain potential correlates of two states of conscious awareness in memory. *Proceedings of the National Academy of Sciences of the United States of America*, *94*(11), 5973–5978.

Evans, L. H., Wilding, E. L., Hibbs, C. S., & Herron, J. E. (2010). An electrophysiological study of boundary conditions for control of recollection in the exclusion task. *Brain Research*, *1324*, 43–53.

Friedman, D., Cycowicz, Y. M., & Bersick, M. (2005). The late negative episodic memory effect: The effect of recapitulating study details at test. *Brain Research. Cognitive Brain Research*, *23*(2–3), 185–198.

Hayama, H. R., Johnson, J. D., & Rugg, M. D. (2008). The relationship between the right frontal old/new ERP effect and post-retrieval monitoring: Specific or non-specific? *Neuropsychologia*, *46*(5), 1211–1223.

Herron, J. E., & Rugg, M. D. (2003a). Retrieval orientation and the control of recollection. *Journal of Cognitive Neuroscience*, *15*, 843–854.

Herron, J. E., & Rugg, M. D. (2003b). Strategic influences on recollection in the exclusion task: Electrophysiological evidence. *Psychonomic Bulletin and Review*, *10*(3), 703–710.

Herron, J. E., & Wilding, E. L. (2005). An electrophysiological investigation of factors facilitating strategic recollection. *Journal of Cognitive Neuroscience*, *17*(5), 777–787.

Herron, J. E. (2007). Decomposition of the ERP late posterior negativity: Effects of retrieval and response fluency. *Psychophysiology*, *44*(2), 233–244.

Jacoby, L. L. (1991). A process dissociation framework: Separating automatic from intentional uses of memory. *Journal of Memory and Language*, *30*, 513–541.

Johansson, M., & Mecklinger, A. (2003). The late posterior negativity in ERP studies of episodic memory: Action monitoring and retrieval of attribute conjunctions. *Biological Psychology*, *64*(1–2), 91–117.

Johansson, M., Stenberg, G., Lindgren, M., & Rosén, I. (2002). Memory for perceived and imagined pictures: An event-related potential study. *Neuropsychologia*, *40*, 986–1002.

Johnson, M. K., Foley, M. A., Suengas, A. G., & Raye, C. L. (1988). Phenomenal characteristics of memories for perceived and imagined autobiographical events. *Journal of Experimental Psychology: General*, *117*(4), 371–376.

Johnson, M. K., Hashtroudi, S., & Lindsay, D. S. (1993). Source monitoring. *Psychological Bulletin*, *114*(1), 3–28.

Johnson, M. K., Kounios, J., & Reeder, J. A. (1994). Time-course studies of reality monitoring and recognition. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, *20*(6), 1409–1419.

Kompus, K., Eichele, T., Hugdahl, K., & Nyberg, L. (2011). Multimodal imaging of incidental retrieval: The low route to memory. *Journal of Cognitive Neuroscience*, *23*(4), 947–960.

Kuo, T. Y., & Van Petten, C. (2008). Perceptual difficulty in source memory encoding and retrieval: Prefrontal versus parietal electrical brain activity. *Neuropsychologia*, *46*(8), 2243–2257.

Leynes, P. A., & Bink, M. L. (2002). Did I do that? An ERP study of memory for performed and planned actions. *International Journal of Psychophysiology*, *45*(3), 197–210.

Leynes, P. A., Cairns, A., & Crawford, J. T. (2005). Event-related potentials indicate that reality monitoring differs from external source monitoring. *The American Journal of Psychology*, *118*(4), 497–524.

Leynes, P. A., & Phillips, M. C. (2008). Event-related potential (ERP) evidence for varied recollection during source monitoring. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, *34*(4), 741–751.

McDaniel, M. A., Waddill, P. J., & Einstein, G. O. (1988). A contextual account of the generation effect: A three-factor theory. *Journal of Memory and Language*, *27*, 521–536.

Mammarella, N., & Fairfield, B. (2006). The role of encoding in reality monitoring: A running memory test with Alzheimer's type dementia. *Quarterly Journal of Experimental Psychology*, *59*(10), 1701–1708.

Mecklinger, A. (2006). Electrophysiological measures of familiarity memory. *Clinical EEG and Neuroscience*, *37*(4), 292–299.

Mecklinger, A., Johansson, M., Parra, M., & Hanslmayr, S. (2007). Source-retrieval requirements influence late ERP and EEG memory effects. *Brain Research*, *1172*, 110–123.

Moscovitch, M. (1992). Memory and working-with-memory: A component process model based on modules and central systems. *Journal of Cognitive Neuroscience*, *4*(3), 257–267.

Paivio, A., Rogers, T. B., & Smythe, P. C. (1968). Why are pictures easier to recall than words? *Psychonomic Science*, *11*, 1–2.

Ranganath, C., & Paller, K. A. (2000). Neural correlates of memory retrieval and evaluation. *Cognitive Brain Research*, *9*, 209–222.

Richardson-Klavehn, A., & Gardiner, J. M. (1995). Retrieval volition and memorial awareness in stem completion: An empirical analysis. *Psychological Research*, *57*(3–4), 166–178.

Riefer, D. M., Chien, Y., & Reimer, J. F. (2007). Positive and negative generation effects in source monitoring. *Quarterly Journal of Experimental Psychology*, *60*(10), 1389–1405.

Rosburg, T., Mecklinger, A., & Johansson, M. (2011). Electrophysiological correlates of retrieval orientation in reality monitoring. *NeuroImage*, *54*, 3076–3084.

Rossion, B., & Pourtois, G. (2004). Revisiting Snodgrass and Vanderwart's object pictorial set: The role of surface detail in basic-level object recognition. *Perception*, *33*(2), 217–236.

Rugg, M. D., Mark, R. E., Walla, P., Schloerscheidt, A. M., Birch, C. S., & Allan, K. (1998). Dissociation of the neural correlates of implicit and explicit memory. *Nature*, *392*(6676), 595–598.

Rugg, M., & Wilding, E. (2000). Retrieval processing and episodic memory. *Trends in Cognitive Sciences*, *4*(3), 108–115.

Rugg, M. D., & Curran, T. (2007). Event-related potentials and recognition memory. *Trends in Cognitive Sciences*, *11*(6), 251–257.

Senkfor, A. J., & Van Petten, C. (1998). Who said what? An event-related potential investigation of source and item memory. *Journal of Experimental Psychology. Learning, Memory, and Cognition*, *24*(4), 1005–1025.

Slamecka, N. J., & Graf, P. (1978). The generation effect: Delineation of a phenomenon. *Journal of Experimental Psychology: Human Learning and Memory*, *4*, 592–604.

Snodgrass, J. G., & Corwin, J. (1988). Pragmatics of measuring recognition memory: Applications to dementia and amnesia. *Journal of Experimental Psychology: General*, *117*(1), 34–50.

Snodgrass, J. G., & Vanderwart, M. (1980). A standardized set of 260 pictures: Norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of Experimental Psychology. Human Learning and Memory*, *6*(2), 174–215.

Trott, C. T., Friedman, D., Ritter, W., & Fabiani, M. (1997). Item and source memory: Differential age effects revealed by event-related potentials. *Neuroreport*, *8*(15), 3373–3378.

Tulving, E. (1972). Episodic and semantic memory. In E. Tulving, & W. Donaldson (Eds.), *Organization of memory*. New York: Academic Press.

Van Petten, C., Senkfor, A. J., & Newberg, W. M. (2000). Memory for drawings in locations: Spatial source memory and event-related potentials. *Psychophysiology*, *37*(4), 551–564.

Vinogradov, S., Luks, T. L., Schulman, B. J., & Simpson, G. V. (2008). Deficit in a neural correlate of reality monitoring in schizophrenia patients. *Cerebral Cortex*, *18*(11), 2532–2539.

Wilding, E. L. (2000). In what way does the parietal ERP old/new effect index recollection? *International Journal of Psychophysiology*, *35*(1), 81–87.

Wilding, E. L., Fraser, C. S., & Herron, J. E. (2005). Indexing strategic retrieval of colour information with event-related potentials. *Brain Research. Cognitive Brain Research*, *25*(1), 19–32.

Wilding, E. L., & Rugg, M. D. (1997). An event-related potential study of memory for words spoken aloud or heard. *Neuropsychologia*, *35*(9), 1185–1195.

Woodruff, C. C., Hayama, H. R., & Rugg, M. D. (2006). Electrophysiological dissociation of the neural correlates of recollection and familiarity. *Brain Research*, *1100*(1), 125–135.