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Strategic retrieval and retrieval orientation in reality monitoring studied by event-related potentials (ERPs)

Timm Rosburg [a,*], Mikael Johansson [b], Axel Mecklinger [a]

[a] Department of Psychology, Experimental Neuropsychology Unit, Saarland University, D-66041 Saarbrücken, Germany
[b] Department of Psychology, Neuropsychology Division, Lund University, SE-22100 Lund, Sweden

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ABSTRACT

Reality monitoring requires the differentiation between perceived and imagined events or between our own actions and the actions of others. The role of control processes in reality monitoring is yet not fully understood. In the current event-related potential (ERP) study, we investigated such control processes in the form of retrieval orientation and strategic retrieval of nontarget information. At study, complete or incomplete object words were presented in sentences. Participants had to identify the words as the subject of the sentence (perceive condition) or had to complete them upon presentation of a word fragment (self-generate condition). The participants' memory accuracy was better for generated items than for perceived items, as tested in a subsequent memory exclusion task. Comparison of ERPs to new items between the two test conditions (i.e. assessing retrieval orientation) showed more positive ERPs when generated object names were targeted. Retrieval orientation also modulated the early midfrontal old/new effect: Items of the self-generate condition elicited this effect irrespective of their target/nontarget status, while in response to the less well remembered items of the perceive condition it was only found when these items were defined as targets. Target retrieval (as reflected in the left-parietal old/new effect) occurred in both test conditions, but nontarget retrieval was observed only for generated items (when perceived items were targeted). Current findings indicate that retrieval orientation can modulate familiarity-related processes. The selective occurrence of nontarget retrieval for generated items corroborates the concept that the ease with which nontarget information can be accessed promotes nontarget retrieval.

1. Introduction

You find yourself at the speaker's desk of a large conference, giving a presentation. Unfortunately, you realize that you do not have the slightest clue about the content of the beamed slides. Needless to say, you do not make a great job and, as a consequence, you feel awfully ashamed. The good thing is, after waking up in the morning, you realize that everything was just a dream. Yet, the dream has left an unpleasant feeling that stays with you during breakfast. So, how do we actually know that a dream was just a dream when it sometimes feels like a real experience?

Reality monitoring describes the ability to discriminate between perceived and imagined events in memory (Johnson & Raye, 1981). This monitoring represents a special case of source monitoring, i.e. the attribution of mnemonic information to various sources. According to the source memory framework, source monitoring reflects a set of processes involved in making attributions about the origin of memories, knowledge, and beliefs (Johnson, Hashtroudi, & Lindsay, 1993). It is proposed that the origin of information is not tagged and read out from memory, but that source attributions are made on the basis of the relative presence of various memory characteristics, in combination with judgment processes (Johnson et al., 1993). Memories for perceived and imagined events differ with regard to their amount of contextual information (time and place), semantic details, sensory information, and cognitive operations (Johnson & Raye, 1981). Getting back to the example of an academic's nightmare above, dreams and the associated mental images might contain rather detailed semantic and sensory information, making them vivid. However, in contrast to an episode experienced in real life, the dream lacks of contextual information. Most strikingly, since such a dream usually stops at its worst part, the dream episode does not contain information about what happened *after* the dreadful event.

Yet, the differentiation between perceived and imagined events is not always trivial. Patients with schizophrenia (Keefe, Arnold, Bayen, McEvoy, & Wilson, 2002; Vinogradov, Luks, Schulman, & Simpson, 2008) or Alzheimer's disease (Mammarella & Fairfield, 2006; Mitchell, Hunt, & Schmitt, 1986) are prone to reality monitoring errors, but reality monitoring might also fail in non-clinical

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* Corresponding author. Tel.: +49 681 302 64367.
E-mail address: trosburg@mx.uni-saarland.de (T. Rosburg).

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conditions. For example, under high memory load during encoding and with a long retention interval, healthy subjects remember having seen a picture although they had actually only read about it (Intraub & Hoffman, 1992). This systematic deficit in source attribution is assumed to occur by imaging during reading and might be ameliorated by metacognitive strategies (Intraub & Hoffman, 1992). Thus, for a thorough understanding of reality monitoring and reality monitoring deficits, knowledge about cognitive control processes, but also about brain structures involved in reality monitoring is indispensable.

FMRI with its superior spatial resolution is well suited for the identification of such brain structures, whereas event-related potential (ERP) recordings are highly valuable for dissociating the temporal aspects of reality monitoring. Previous fMRI studies have consistently identified the medial anterior prefrontal cortex (PFC) as one brain region involved in reality monitoring, while more lateral PFC regions have been reported to support source monitoring in general (Kensinger & Schacter, 2006; Lagioia et al. 2011; Simons, Davis, Gilbert, Frith, & Burgess, 2006; Simons, Gilbert, Owen, Fletcher, & Burgess, 2005; Simons, Henson, Gilbert, & Fletcher, 2008; Simons, Owen, Fletcher, & Burgess, 2005; Turner, Simons, Gilbert, Frith, & Burgess, 2008; Vinogradov et al., 2008; but see Christoff, Ream, Geddes, & Gabrieli, 2003; Lundstrom et al., 2003). The involvement of the medial anterior PFC in reality monitoring is also supported by neuropsychological data, showing that lesions in this region are associated with spontaneous confabulation (Schnider, 2003; see also Buda, Fornito, Bergström, & Simons, 2011). In contrast, ERP studies in reality monitoring have been less sensitive in uncovering a differential involvement of brain structures for the retrieval of self-generated and externally perceived items: ERPs' correlates of recollection hardly differed in their topography between these two types of information, suggesting overlapping neural generators (Johansson, Stenberg, Lindgren, & Rosén, 2002; Wilding & Rugg, 1997).

However, when interpreting the findings of reality monitoring studies, it is important to note that sometimes different retrieval processes have been contrasted. Some studies have contrasted brain activation in reality monitoring tasks with brain activation in external or internal source memory tasks (e.g. fMRI: Simons et al., 2006; ERP: Leynes, Cairns, & Crawford, 2005). Thus, retrieval-related brain activation was compared between two different tasks. Other studies have contrasted brain activation associated with the retrieval of self-generated information with the retrieval of externally perceived information within reality memory tasks (e.g. fMRI: Kensinger & Schacter, 2006; ERP: Johansson et al., 2002). Thus, such studies compared for example retrieval-related brain activation of items that had been perceived at encoding with retrieval-related brain activation of items that had been imagined at encoding. Such retrieval-related brain activation is commonly quantified by contrasting activity in response to studied items with activity elicited by new items (so-called old/new effects). An often neglected aspect in research on memory retrieval is that reality monitoring might be influenced by strategic retrieval processes. Strategic retrieval processes have been conceptualized as control processes allowing the retrieval of information that is relevant for a specific situation and for the specific memory judgment at hand (Moscovitch, 1992; Moscovitch & Melo, 1997; Herron & Wilding, 2005). Such strategic control processes might also be engaged in order to overcome interference between competing memories (Bergström, O'Connor, Li, & Simons, 2012).

By using ERPs, we recently investigated two kinds of strategic retrieval processes in reality monitoring, namely retrieval orientation and strategic recollection (Rosburg, Mecklinger, & Johansson, 2011a, 2011b). The two processes were studied in a memory exclusion task (Jacoby, 1991). In this type of memory task, participants encode items in two (or more) conditions; at test, participants have to identify items of one study condition as targets and to reject items of the other condition(s) together with new items.

Retrieval orientation is defined as the specific form of processing that is applied to a retrieval cue when specific episodic information is targeted (Rugg & Wilding, 2000). Processing of cues might depend on task requirements (e.g. recognition vs. source memory test) or on the encoded information (e.g. perceived vs. imagined word-picture associations). Retrieval orientation is presumed to affect the processing of all test cues presented during memory tasks, but to be reflected most purely when the cortical responses to unstudied items are contrasted between different episodic tasks. The processing of these unstudied items is not confounded by variations related to retrieval success. In our previous study, participants studied object names that were presented together with a picture of the denoted object ('perceived items') and object names that were followed by the instruction to create a mental image ('imagined items'). At test, they had to identify perceived items as targets and to reject imagined items and unstudied items as nontargets, or they had to identify imagined items as targets and to reject all other items as nontargets (Rosburg et al., 2011a). We found that participants remembered imagined items less accurately than perceived items. ERPs to new items were more positive from 600 to 1100 ms over frontal electrode sites when items of the imagine condition were targeted. This retrieval orientation effect was modulated by retrieval effort, with larger ERP differences between conditions associated with higher levels of task difficulty (Rosburg et al., 2011a).

Second, we addressed the aspect of strategic recollection (Rosburg et al., 2011b). This concept refers to the idea that memory retrieval can be controlled strategically, primarily in order to optimize the retrieval success, but also in order to minimize the retrieval effort. Strategic retrieval has been investigated in particular in memory exclusion tasks. In this type of task, retrieval of nontarget source information is potentially beneficial, as it promotes a swift rejection decision for nontargets ('recall-to-reject strategy', Clark, 1992). Alternatively, subjects might endorse an item as 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). This second strategy makes the retrieval of nontarget information dispensable and has the benefit that the rememberer can constrain the retrieval processes on one source. Herron and Rugg (2003b) argued that nontarget information is retrieved when retrieval of target information is difficult and, as consequence, target information alone does not provide a reliable basis for classifying items as targets and nontargets (see also Dzulkifli & Wilding, 2005; Dzulkifli, Herron, & Wilding, 2006; Wilding, Fraser, & Herron, 2005). Thus, strategic recollection might be described as the optimization of retrieval either by the prioritization of target information or, when target accuracy is low, by a recall-to-reject strategy for nontarget information. In ERP studies, strategic recollection is tested by assessing if nontargets in memory exclusion tasks elicit a left-parietal old/new effect (500–800 ms), an ERP effect commonly regarded as a correlate of recollection (Friedman & Johnson, 2000; Mecklinger & Jäger, 2009).

Yet, an impact of target accuracy on nontarget retrieval has not been shown in all ERP studies (Herron & Wilding, 2005; Sprondel, Kipp, & Mecklinger, 2012), suggesting that strategic recollection might depend on other task factors as well. Herron and Wilding (2005) proposed that high distinctiveness of target and nontarget information makes nontarget retrieval less likely. However, this view was not supported by our recent study. We observed that nontarget information was retrieved when imagined items were targeted, but not when perceived items were targeted (Rosburg et al., 2011b).

Only the target/nontarget designation varied between two test conditions, while the underlying memory sources were the same. Consequently, the distinctiveness between target and nontarget information did not vary between test conditions and could not have been the driving factor for the selective nontarget retrieval evident in just one test condition.

As an alternative account, we have proposed that it is the ease with which perceived items could be accessed that promoted their retrieval as nontargets (Rosburg et al., 2011b). This account was based on the observation that the left-parietal old/new effect to nontargets was correlated with retrieval accuracy in both test conditions. The ease of nontarget accessibility might be determined to a major extent by the strength of the encoded information (and here in particular of the cue-item association), but also by other factors such as interferences with other memory contents, retrieval orientation, or priming (for the differentiation of availability and accessibility, see Tulving & Pearlstone, 1966). We argued that the retrieval of nontarget information might be supported by bottom-up mechanisms, in the sense that subjects do not actively search for source information of nontargets, but that the mere presentation of nontarget cues reactivates this information (cf. incidental recollection, e.g. Kompus, Eichele, Hugdahl, & Nyberg, 2011; Richardson-Klavehn & Gardiner, 1995). Thus, subjects do not need to strategically emphasize nontarget retrieval; they simply make use of information that comes effortlessly to mind when the cue is presented (Rosburg et al., 2011b).

Such a bottom-up mechanism of nontarget retrieval differs from those suggested by other models of strategic retrieval: Herron and Rugg (2003b) proposed that the absence of parietal nontarget old/new effects most likely reflects an ‘attentional bias’ (Anderson & Bjork, 1994). By this account, nontarget information is retrieved both when target accuracy is high and low, but is only attended when target accuracy is low. This implicates, however, that the rememberer evaluates his/her target accuracy and reacts on lower levels of target accuracy by broadening the attentional focus. As a second account for selective retrieval of target information, Herron and Rugg (2003b) proposed that participants might have adopted a retrieval orientation that focused retrieval attempts on target items (‘cue bias’, Anderson & Bjork, 1994). Finally, in development of bias accounts of Herron and Rugg (2003b), it has been suggested that the degree of target prioritization is modulated by the resources available for cognitive control, as measured by working memory capacity (Elward & Wilding, 2010; Elward, Evans, & Wilding, 2012). This view is based on the finding that across individuals the degree to which the left parietal old/new effects was larger for targets than for nontargets increased with working memory capacity.

The proposed models of nontarget retrieval do not necessarily rule out each other: We have previously argued that bottom-up nontarget retrieval might be complemented by top down controlled (voluntary) retrieval of nontarget information (Rosburg et al., 2011b). However, we suggest that qualitatively different mechanisms can underlie nontarget retrieval and that some instances of nontarget retrieval are the result of easy accessibility of nontarget information rather than governed by low target accuracy. For some retrieval situations, the models of Herron and Rugg (2003b) and of our own make the same predictions: Both models for example predict that nontarget retrieval will occur when target accuracy is low and nontarget accuracy is high. Nevertheless, the two models might be dissociated on grounds of how the magnitude of nontarget retrieval co-varies with the ease of nontarget retrieval and the difficulty of target retrieval. According to our model, the magnitude of nontarget retrieval should correlate positively with measures that describe how well nontarget information can be assessed. Two putative measures for the accessibility of nontarget information are the discrimination index Pr (hit rate for these items – false alarm rate to nontargets) and the left-parietal old/new effect in response to these items when they are defined as targets. In contrast, according to the model of Herron and Rugg (2003b), lower levels of target accuracy should lead to higher levels of nontarget retrieval. Consequently, the magnitude of nontarget retrieval should correlate negatively with measures that describe how well the target information is accessible. Here, primarily the left-parietal old/new effect in response to targets should be considered as reliable measure for target accessibility, since the Pr score might be affected by nontarget retrieval. Finally, ERP measures of retrieval orientation and nontarget recollection should co-vary if nontarget retrieval reflects the consequence of adopting retrieval orientation (as discussed by Herron & Rugg, 2003b).

Our current study aimed at clarifying the role of retrieval orientation and strategic recollection in reality monitoring and at evaluating how retrieval accuracy for target and nontarget information affects these processes. Our major hypothesis is that the accessibility of information determines whether a rememberer relies more on self-generated or more on perceived information in reality monitoring tasks.

In detail, the first aim of our study was to further clarify the potential impact of retrieval effort on retrieval orientation in reality monitoring. As outlined, we previously observed better retrieval accuracy for perceived than for imagined items (Rosburg et al., 2011a, 2011b). This was presumably caused by the high perceptual richness and homogeneity of the object pictures used as stimulus materials in the perceive condition that facilitated their accessibility. This picture superiority effect (Paivio, Rogers, & Smythe, 1968) outbalanced the typical generation effect (Slamecka & Graf, 1978), which is the usually observed better retrieval accuracy for generated than for perceived material. The behavioral difference between the two test conditions in our previous study leaves open the possibility that the found ERP effect to new items could have been the consequence of the higher level of retrieval effort for imagined items, rather than being genuinely associated with retrieval orientation (Sprondel et al., 2012). If, however, the previously found ERP effect reflected a genuine retrieval orientation effect, it should also be observed when the retrieval of self-generated items is less effortful than the retrieval of perceived items. Therefore, we designed a study in which we sought to achieve that participants retrieved self-generated items more accurately than perceived items.

The second and major aim of our study was to investigate the impact of retrieval difficulty on strategic recollection in a reality monitoring task. We hypothesized that self-generated items, but not perceived items, would be retrieved as nontargets because the accessibility of self-generated items was expected to be easier than the accessibility of perceived items in the current design. For the second purpose, we analyzed also the effects of strategic recollection on other ERP effects related to recognition memory, such as the early midfrontal old/new effect (400–500 ms), the late right prefrontal old/new effect (900–1500 ms), and the late posterior negativity (LPN, 900–1500 ms). In order to further elucidate the mechanism of nontarget retrieval, we correlated ERP measures of nontarget retrieval with measures of target and nontarget accuracy, as well as the ERP retrieval orientation effect.

2. Methods

2.1. Participants

Thirty-two volunteers (16 female), ranging in age from 19 to 33 years (mean age 23 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 participants but two were right handed and all had normal or corrected-to-normal vision. Data of another 16 participants were discarded due to excessive artifacts during recordings ($n=3$) or due to their poor performance in one ($n=12$) or both ($n=1$) of the memory tasks, resulting in a too small number of trials for calculating the ERPs. Participants were informed about the procedure of the experiment and gave written consent for participation. Participation was compensated with 8 €/hour or with course credit.

2.2. Experimental procedure

The experiment was composed of two blocks consisting of a study and test phase: During the study phase, German object names were presented in two conditions: In the perceive condition, participants had to identify and name the subject of a sentence (which was always a concrete object). The German grammar allows the subject of a sentence to be placed in front or after the verb (e.g. “Wein wird aus Trauben gemacht.” Or “Aus Trauben wird Wein gemacht.”; see Fig. 1A for examples in English). Thus, participants had to read the sentence before they could identify its subject. In the self-generate condition, participants had to name an only incompletely presented object word in a sentence (e.g. “B_ _ r wird aus Hopfen gebraut.”). The incomplete word was always indicated by at least the first and last letter, and underscore characters indicated the number of missing letters. Due to this structure, there was only one possible correct response, as assured by pilot tests. An incomplete word was always the subject of the sentence. In both conditions, participants had to name the identified study word.

Study trials started with the presentation of a fixation cross for 750 ms. Thereafter, a sentence was presented for a maximum duration of 10 s. Participants initiated the next trial by pressing the space bar on a keyboard or trials ended at latest after 10 s. When participants failed to respond within this time or named an incorrect word, the experimenter provided the correct response. The time between the sentence onset and pressing the space bar defined the reaction time in study trials. Trials were separated by 3000 ms intervals. Trials of the two study conditions occurred in random order, with the restriction that a maximum of three trials of the same condition occurred in succession. Participants were informed that the study phase was followed by a recognition test, but without qualifying the exact nature of this test. However, they were encouraged to pay full attention to the study tasks, because that would also support their recognition performance later on.

Participants were tested in a memory exclusion task with the target category switching after half of the trials: In the perceived item target (PT) condition, participants had to identify object names that had been presented in the perceive condition and to reject object names of the self-generate condition together with new object names. In the self-generate item target (ST) condition, participants had to identify object names that had been presented in the self-generate condition and to reject object names of the perceive condition together with newly presented object names. As illustrated in Fig. 1, cue presentation did not differ between the two test conditions. Participants were instructed to respond as fast and accurately as possible. In the test phase, trials started with a fixation cross, lasting for 1000 ms and followed by an empty screen for 500 ms. Object names were presented for 200 ms. There was a time limitation of 3800 ms for giving a response. No response feedback was provided. Participants responded by pressing the letters “C” and “M” on a computer keyboard with the left and right index finger. The assignment of the key to the response category (Targets vs. Nontargets) was balanced across participants. The whole experiment took about 2.5 h (including preparation time for EEG recording).

2.3. Stimuli

Verbal material was presented on a 17 in. monitor in white 18 pt Courier New font on a black background. All displays were at the center of the computer screen, with participants sitting 60–80 cm in front of it. Study items consisted of object names with a word length between 3 and 10 characters and a word frequency ranging from 1 to 336 occurrences per million. Word frequency was checked with the Celex linguistic database by Baayen, Piepenbrock, and Rijn (1993). A total of 184 object names were selected as study items. Object names were grouped into two lists of 92 items. One list was assigned to the perceive condition (complete sentences) and the second list to the self-generate condition (incomplete sentences). The list assignment to the study conditions was counterbalanced across participants. Furthermore, the word length and word frequency of the two lists did not differ between lists and their halves. There were two study-test blocks in each session. The order of test conditions was counterbalanced across individuals, but remained the same within them. 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 labeled as nontargets), together with 46 new items that had to be rejected.

2.4. EEG recordings

Prior to the study phase, an elastic cap (Easycap, Herrsching, Germany) with 58 embedded silver/silverchloride EEG electrodes was attached to the participant’s head. Electrode locations in these caps are based on an extended 10–20 system (10–10 system). EEG was continuously recorded, referenced to the left mastoid. In addition, electroocular activity was recorded by a pair of electrodes affixed to the outer canthi and by a pair of electrodes placed below and above the right eye. Data were sampled at 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 at 50 Hz to suppress line activity, and re-referenced to linked mastoids. The impact of eye movements and blinks on EEG activity was eliminated by a correction algorithm implemented in the analysis tool (Vision-Analyzer 2.01, Brain Products, Gilching, Germany); this algorithm is based on an independent component analysis (ICA). 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

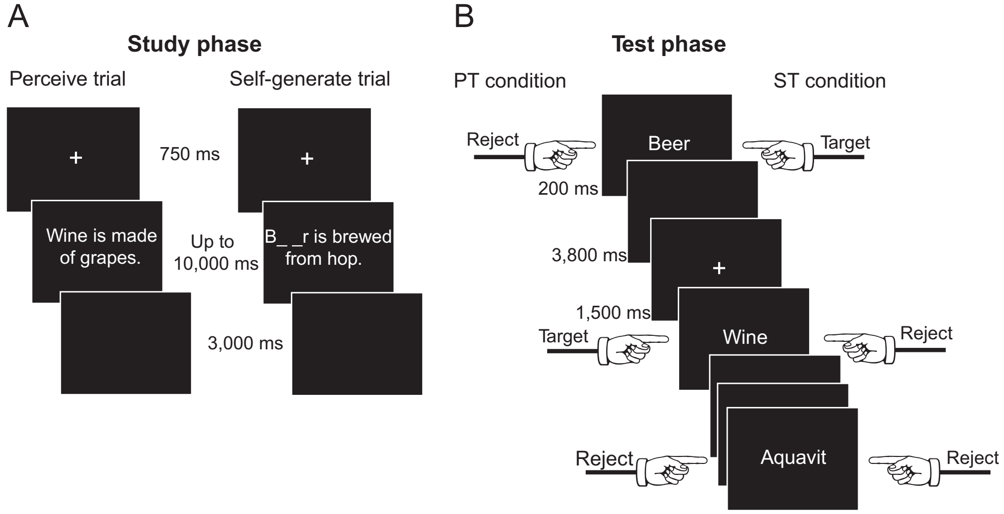

Fig. 1. Schematic illustration of the experimental set-up: (A) During the study phase, object names were presented in complete or incomplete sentences. When the sentences were complete, participants had to identify the subject of the sentence. When the sentences were incomplete, subjects had to find out which word fit into the sentence. The initial and last letters of the words were provided together with the number missing letters. The two kinds of sentences were mixed during the study blocks. (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 self-generated item target condition (ST 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.

segmented into epochs of 3000 ms duration, including a 500 ms baseline. Data were baseline corrected and screened for artifacts that had remained undetected by the ICA procedure. Trials with EEG activity exceeding ± 100 μV, exhibiting abnormal trends (R^2 limit = 0.3), or being abnormally distributed (± 5 SD from the mean) were excluded. For each test condition, average ERPs were calculated for correctly identified targets (hits), as well as for correct rejections of nontargets and new items. Individual ERPs were only considered for analysis if a minimum of 14 trials was accepted.

2.5. *Data analysis*

Behavioral data: For each test condition separately, the discrimination index (Pr) was quantified as the difference between the hit rate (P_target) and the false alarm rate to nontargets (P_false alarm) (Snodgrass & Corwin, 1988), with the test conditions designated by the indices PT (perceived item target condition) and ST (self-generated item target condition). Behavioral responses were compared between the two conditions by means of paired t-tests and repeated measure analysis of variance (ANOVA). The discriminations indices in each condition (Pr_{PT}, Pr_{ST}), and their difference ($\Delta\mathrm{Pr}=\mathrm{Pr}_{ST}-\mathrm{Pr}_{PT}$) were used to analyze the co-variation of ERP measures with behavioral measures. In order to avoid over- and underestimations of this co-variation, single statistical outliers (± 3 SD from the mean) were excluded from this analysis.

ERP data: In order to explore the retrieval orientation effect, ERPs to new items were contrasted between the PT and ST conditions. Based on previous ERP studies of retrieval orientation, we focused on the time window between 400 and 1000 ms. For this time span, ERP to new items were initially analyzed for 100-ms time bins each. In order to assess the topography of the retrieval orientation effect, ERP data of 5 × 5 electrodes (F7, F3, Fz, F4, F8, FC7, FC3, FCz, FC4, FC8, T7, C3, Cz, C4, T8, TP8, CP3, CPz, CP4, TP8, P7, P3, Pz, P4, P8) were entered in an ANOVA with RETRIEVAL ORIENTATION (ST vs. PT), LATERALITY (Left vs. Left-medial vs. Midline vs. Right-medial vs. Right electrodes), and ANTERIOR/POSTERIOR (Frontal vs. Fronto-Central vs. Central vs. Centro-Parietal vs. Parietal electrodes) as within subject factors. Subsequently, ERP data were collapsed across 100-ms time bins with a significant RETRIEVAL ORIENTATION effect. For sake of brevity, only the results for this longer time window are presented. The Greenhouse–Geisser adjustment for nonsphericity was used when necessary, as indicated by reporting the ε value, and the corrected p values are reported together with the uncorrected degrees of freedom.

In order to analyze strategic retrieval, old/new effects for targets and nontargets were compared between the two conditions. In detail, we analyzed the old/new effects between 300 and 900 ms in 100-ms time bins at the electrodes FCz and P5 by a repeated-measure ANOVA with STIMULUS (Target, Nontarget, New items) and CONDITION (PT, ST) as within-subject factors. By this analysis, we aimed to establish in particular the temporal characteristics of the early mid-frontal and late parietal old/new effects. This initial analysis led to the definition of two non-overlapping latency windows for these effects, namely from 400 to 500 ms for the early midfrontal effect (measured at FCz) and from 500 to 800 ms for the late parietal old/new effect (measured at P5). Furthermore, we compared the late posterior negativity (900–1500 ms) at electrode POz, and the late right frontal old/new effect (900–1500 ms) at electrode F6 between stimuli and conditions. For these later effects, the selected electrode positions and latency windows were the same as in our previous analysis (Rosburg et al., 2011b). In addition to these more prototypical old/new effects, the analysis was in some cases extended to other electrodes and time windows post-hoc in order to provide a more comprehensive picture of the ERP old/new effects. More specifically, ERPs in the time windows from 700 to 1000 ms and from 900 to 1500 ms at two midfrontal electrodes (F1 and Fz) were also tested on STIMULUS (Target, Nontarget, New items) and CONDITION (PT, ST) effects. For the correlation analyses between ERP measures of nontarget retrieval and behavioral measures, as well as the ERP retrieval orientation effect, Pearson's correlation coefficients were calculated.

3. Results

3.1. *Behavioral data study phase*

In the study phase, it was harder for the participants to generate the correct object word fitting into the sentence than to detect the subject in the complete sentences. Both the number of incorrect responses and the number of time-outs were higher in the self-generate condition than in the perceive condition (incorrect responses: 4.6 ± 2.9 vs. 1.7 ± 1.9, $t_{31}=4.874$, $p<0.001$; time-outs: 4.8 ± 3.5 vs. 0.3 ± 0.8, $t_{31}=6.789$, $p<0.001$, respectively). When excluding the time-outs, response times were still slower for the self-generate condition (RT = 3696.7 ± 562.2 ms vs. RT = 3494.1 ± 824.5 ms, $t_{31}=2.616$, $p=0.014$).

Table 1
Mean accuracy of responses in the perceived item target condition (PT) and self-generated item target condition (ST) (± SD): P_target (proportion of correctly identified targets), P_false alarms (proportion of false alarms to old nontargets), Pr (discrimination index), P_new (proportion of correctly rejected new items), P_no response (proportion of omitted responses).

	PT	ST
P_target	0.52 ± 0.13	0.84 ± 0.09
P_false alarm	0.20 ± 0.13	0.17 ± 0.11
Pr	0.32 ± 0.21	0.67 ± 0.16
P_new	0.89 ± 0.09	0.96 ± 0.05
P_no response	0.006 ± 0.011	0.001 ± 0.002

Table 2
Mean reaction times (± SD) for correctly identified targets (RT_Target), correctly rejected old nontargets (RT_Nontarget) and new items (RT_New) in the perceived item target condition (PT) and self-generated item target condition (ST).

	PT	ST
RT_Target	1274.3 ± 333.3	890.1 ± 201.4
RT_Nontarget	1182.6 ± 262.4	1015.2 ± 297.3
RT_New	972.0 ± 232.2	801.1 ± 177.9

3.2. *Behavioral data test phase*

The analysis of the behavioral data of the test phase revealed a higher hit rate for targets in the ST condition than in the PT condition ($t_{31}=13.352$, $p<0.001$, Table 1), while the rate of false alarms did not differ between conditions ($t_{31}=1.373$, n.s.). As a consequence, the discrimination index was higher in the ST than in the PT condition ($t_{31}=12.617$, $p<0.001$); thus, participants demonstrated a reliable generation effect. In addition, the percentage of correctly rejected new items was higher when self-generated items were targeted ($t_{31}=5.362$, $p<0.001$). Only on very few occasions participants omitted responses, but the likelihood was again lower in the ST condition ($t_{31}=2.856$, $p=0.008$). The order of test conditions had no effect on the retrieval accuracy.

For reaction times (RTs), a repeated-measure ANOVA with STIMULUS (Target, Nontarget, New items) and CONDITION (PT, ST) as factors revealed significant main effects and an interaction (STIMULUS: $F_{2,\,62}=48.458$, $p<0.001$, $\varepsilon=0.789$; CONDITION: $F_{1,\,31}=102.789$, $p<0.001$; STIMULUS × CONDITION: $F_{2,\,62}=11.398$, $p=0.002$, $\varepsilon=0.726$). The RTs differed between test conditions for all kinds of items, with faster responses in the ST condition than in the PT condition (targets: $t_{31}=9.331$, $p<0.001$; nontargets: $t_{31}=3.608$, $p=0.001$; new items: $t_{31}=7.271$, $p<0.001$, Table 2). In the ST condition, responses were fastest for new items, both compared to nontargets and targets ($t_{31}=7.356$, $p<0.001$ and $t_{31}=3.305$, $p=0.002$, respectively), and responses to targets were faster than to nontargets ($t_{31}=3.065$, $p=0.004$). In the PT condition, responses were also fastest for new items, compared to both nontargets and targets ($t_{31}=5.254$, $p<0.001$ and $t_{31}=7.548$, $p<0.001$, respectively), but in contrast to the ST condition responses to targets were slower than to nontargets ($t_{31}=2.812$, $p=0.008$).

In sum, participants had more difficulties when they retrieved perceived items, as reflected in lower retrieval accuracy and slower response times, as compared to the retrieval of self-generated items.

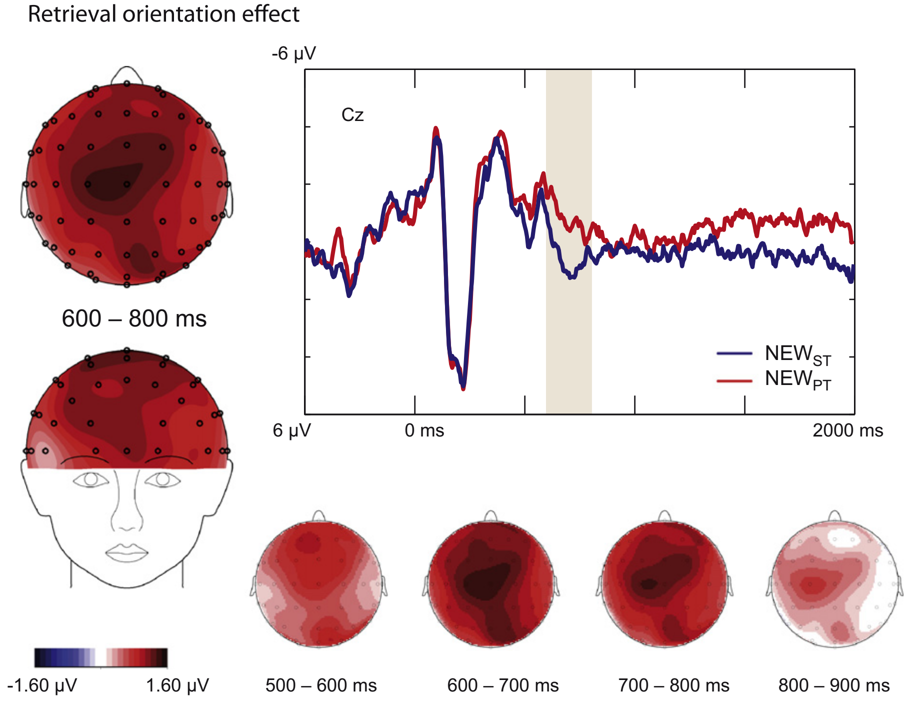

Fig. 2. ERPs to new items in the two target conditions: on the right side, data from the Cz electrode are shown; ERPs to new items in the PT condition are plotted as a red line, ERPs to new items in the ST condition as blue line. The analyzed latency range from 600 to 800 ms is shown as grey shaded area. On the left side, the difference potential between the conditions is depicted for this latency range. Amplitudes are color–coded in these maps. The button row shows the time course of the difference potential between 500 and 900 ms.

3.3. ERP data

3.3.1. Retrieval orientation

ERP to new items (600–800 ms) were found to be more positive in ST condition (when items of the self-generate condition were targeted) than in the PT condition ($F_{1,\ 31}=5.994$, $p=0.020$). In addition, a significant triple interaction between RETRIEVAL ORIENTATION, LATERALITY, and ANTERIOR/POSTERIOR was observed ($F_{16,\ 496}=2.487$, $p=0.023$, $\varepsilon=0.390$). Subsequent pairwise comparisons at each of the 25 electrodes showed a significant RETRIEVAL ORIENTATION effect or a trend for a RETRIEVAL ORIENTATION effect at all electrodes but F8, TP7, and P7, reflecting the fact that the effect was topographically widespread (Fig. 2). The effect was largest in amplitude at electrode Cz ($t_{31}=2.489$, $p=0.019$).

In order to explore the potential impact of retrieval effort on the ERP retrieval orientation effect, correlations between the amplitude of the retrieval orientation effect (the difference of the new item ERPs in the ST and PT condition) at Cz and behavioral measures of retrieval accuracy were calculated. These analyses revealed no significant correlations between the ERP retrieval orientation effect and the measures of retrieval accuracy (Pr_{PT}: $r=-0.100$, n.s.; Pr_{ST}: $r=-0.083$, n.s; $n=32$; ΔPr: $r=0.297$, n.s., $n=31$). As a reminder, we observed a significant *negative* correlation between the ERP retrieval orientation effect and ΔPr in our previous study (Rosburg et al., 2011a).

To sum up the findings on retrieval orientation, ERPs to new items were more positive-going when self-generated items were targeted. This effect had the same polarity and a similar time course as in our previous study, but was topographically more widespread. The ERP retrieval orientation effect was not modulated by retrieval accuracy.

3.3.2. Old/new effects

Early midfrontal old/new effect (400–500 ms): The analysis of the early midfrontal old/new effect was constrained to the 400–500 ms latency range, because no reliable old/new effects were observed before 400 ms. A repeated-measure ANOVA on the mean ERP amplitudes in this latency range at electrode FCz with STIMULUS (Target, Nontarget, New items) and CONDITION (PT, ST) as factors revealed a significant main effect for STIMULUS and a significant interaction between STIMULUS and CONDITION (Table 3). Separate analyses for each condition showed that the midfrontal ERPs to targets were more positive than to nontargets and new items in the ST condition (Fig. 3 top), while midfrontal ERPs both to targets and nontargets were more positive than to new items in the PT condition (Fig. 3bottom, Table 4). A direct comparison showed no difference between the early old/new effects to self-generated items when defined as targets and when defined as nontargets ($t_{31}=0.814$, n.s.). The early midfrontal old/new effect was, however, larger for perceived items as targets than for perceived items as nontargets ($t_{31}=2.939$, $p=0.006$). Taken together, a midfrontal old/new effect was observed for self-generated items irrespectively of target definition, but for perceived items only when they were defined as targets.

Left-parietal old/new effect (500–800 ms): For the mean amplitudes at electrode P5, we again observed a significant main effect of STIMULUS and a significant interaction between STIMULUS and CONDITION (Table 3). The analysis of the left-parietal effect for each condition separately, however, varied from the analysis of the early midfrontal old/new effect: In the ST condition, the left-parietal ERPs to targets were more positive than to nontargets and new items, with no difference between the latter two (Fig. 4top). In contrast, in the PT condition, the left-parietal ERPs to *nontargets* were more positive than to targets and new items, as well as more positive to targets than to new items (Fig. 4bottom). For self-generated items, the left-parietal old/new effect did not vary with target definition ($t_{31}=1.054$, n.s.). The same cross-condition comparison for perceived items revealed that the left-parietal old/new effect was significantly larger for perceived items as targets than for perceived items as nontargets ($t_{31}=3.136$, $p=0.004$).

Table 3
The CONDITION and STIMULUS effects for each analyzed time window; all time windows showing significant CONDITION × STIMULUS interactions were further analyzed in each condition separately (Table 4).

Time	Ch.	STIMULUS	CONDITION	STIMULUS × CONDITION
Early midfrontal old/new effect				
400–500 ms	FCz	$F_{2,\,62}=12.564$ $P<0.001$	$F_{1,\,31}=0.371$ n.s.	$F_{2,\,62}=3.822$ $p=0.023$ ST: NEW, NT $<$ T PT: NEW $<$ NT, T
Left parietal old/new effect				
500–800 ms	P5	$F_{2,\,62}=18.155$ $P<0.001$	$F_{1,\,31}=0.693$ n.s.	$F_{2,\,62}=21.420$ $P<0.001$ $\varepsilon=0.660$ ST: NEW, NT $<$ T PT: NEW $<$ T $<$ NT
Frontal old/new effect				
700–1000 ms	F1	$F_{2,\,62}=2.018$ n.s.	$F_{1,\,31}=0.525$ n.s.	$F_{2,\,62}=9.733$ $P=0.001$ $\varepsilon=0.763$ ST: NEW, NT $<$ T PT: T $<$ NT
LPN				
900–1500 ms	POz	$F_{2,\,62}=24.768$ $P<0.001$ $\varepsilon=0.831$ T, NT $<$ NEW	$F_{1,\,31}=7.139$ $P=0.012$ PT $<$ ST	$F_{2,\,62}=0.571$ n.s.
Late right-frontal old/new effect				
900–1500 ms	F6	$F_{2,\,62}=1.108$ n.s.	$F_{1,\,31}=0.349$ n.s.	$F_{2,\,62}=1.846$ n.s.
Late frontal old/new effect				
900–1500 ms	Fz	$F_{2,\,62}=0.953$ n.s.	$F_{1,\,31}=0.470$ n.s.	$F_{2,\,62}=3.651$ $P=0.047$ $\varepsilon=0.769$ ST: NEW $=$ NT $=$ T PT: NT $<$ T, NEW

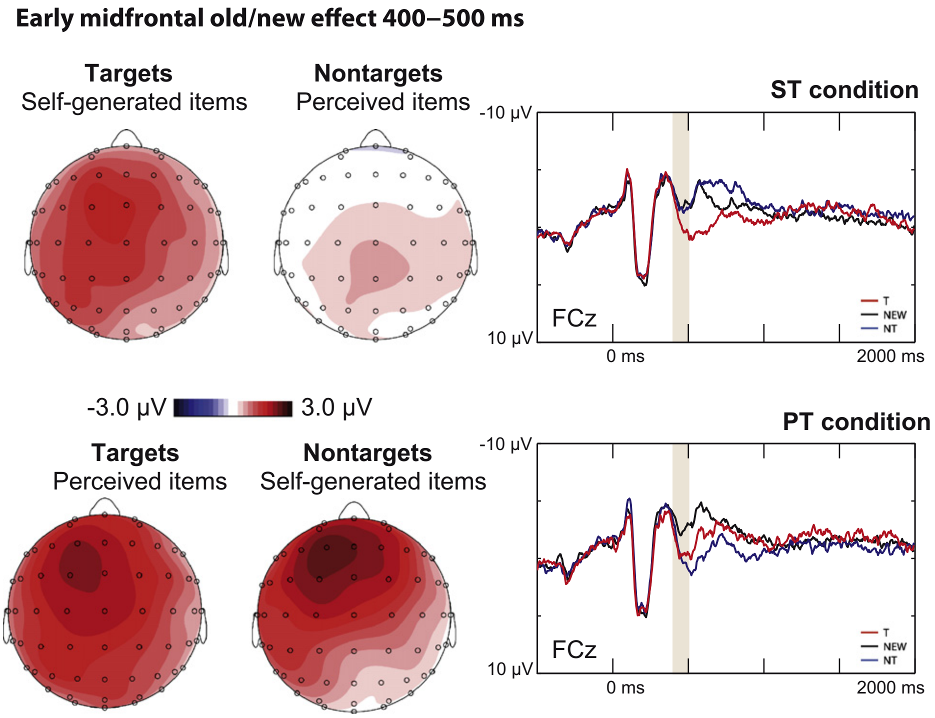

Fig. 3. The early midfrontal old/new effect for targets and nontargets in the two test conditions from 400 to 500 ms: On the left, difference maps are displayed from the top view. On the right, ERPs to targets, nontargets and new items at the electrode FCz are shown, separately for the ST and PT condition. From this figure to Fig. 6, ERPs to targets are depicted as red lines, ERPs to nontargets as blue lines, and ERPs to new items as black lines. The analyzed latency range from 400 to 500 ms is shown as grey shaded area. Early midfrontal old/new effects were observed in response to all old items but to nontargets in the ST condition.

Table 4
STIMULUS effects in each condition for those time windows, showing significant CONDITION × STIMULUS interactions in the initial ANOVA (Table 3).

Time	Ch.	PT	ST
Midfrontal old/new effect			
400–500 ms	FCz	$F_{2,\ 62}=11.270$ $P<0.001$ $\varepsilon=0.770$ NEW < T: $t_{31}=4.124$, $P<0.001$ NEW < NT: $t_{31}=4.278$, $P<0.001$ T < NT: $t_{31}=0.184$, n.s.	$F_{2,\ 62}=5.641$ $P=0.006$ NEW < T: $t_{31}=2.824$, $P=0.008$ NEW < NT: $t_{31}=0.716$, n.s. NT < T: $t_{31}=2.402$, $P=0.022$
Left parietal old/new effect			
500–800 ms	P5	$F_{2,\ 62}=19.315$ $P<0.001$ NEW < T: $t_{31}=3.372$, $P=0.002$ NEW < NT: $t_{31}=5.770$, $P=0.001$ T < NT: $t_{31}=3.137$, $P=0.004$	$F_{2,\ 62}=20.163$ $P<0.001$ $\varepsilon=0.747$ NEW < T: $t_{31}=4.919$, $P<0.001$ NT < NEW: $t_{31}=0.369$, n.s. NT < T: $t_{31}=4.783$, P < 0.001
Frontal old/new effect			
700–1000 ms	F1	$F_{2,\ 62}=7.314$ $P<0.001$ NEW < T: $t_{31}=0.832$, n.s. NEW < NT: $t_{31}=3.746$, $P=0.001$ T < NT: $t_{31}=2.537$, P=0.016	$F_{2,\ 62}=4.795$ $P=0.018$ $\varepsilon=0.816$ NEW < T: $t_{31}=1.545$, n.s. NT < NEW: $t_{31}=1.951$, n.s. NT < T: $t_{31}=2.715$, $P=0.011$
Late frontal old/new effect			
900–1500 ms	Fz	$F_{2,\ 62}=0.243$ n.s.	$F_{2,\ 62}=4.139$ $P=0.021$ NEW < T: $t_{31}=0.011$, n.s. NEW < NT: $t_{31}=2.771$, $P=0.009$ T < NT: $t_{31}=2.139$, $P=0.040$

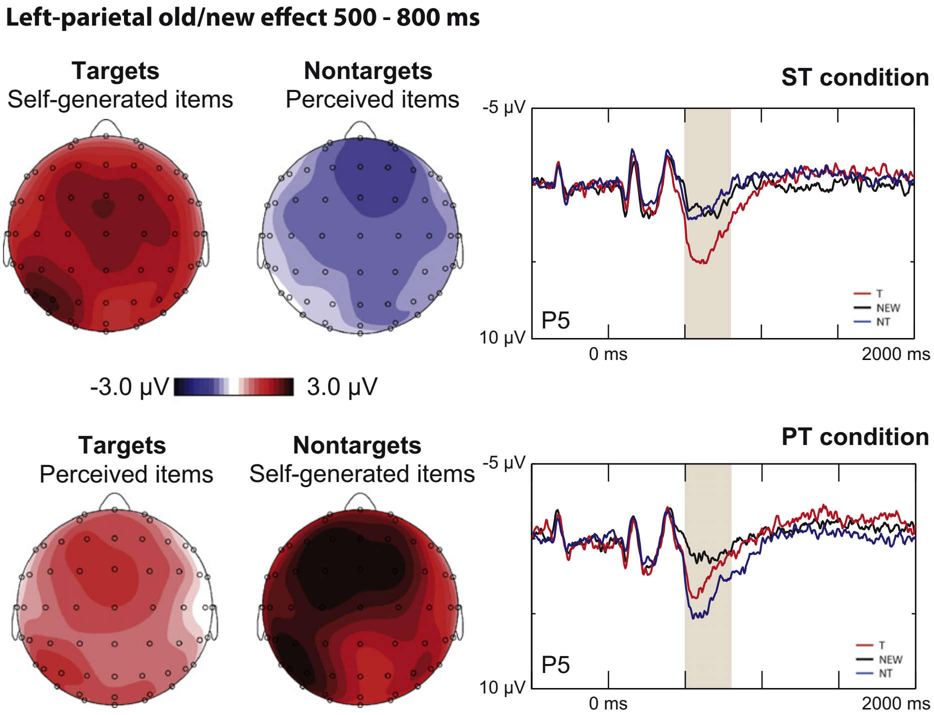

Fig. 4. The left parietal old/new effects for targets and nontargets in the two test conditions, for the 500–800 ms latency range: On the left, difference maps are displayed from the top view. On the right, ERPs to targets, nontargets and new items at the electrode P5 are shown, separately for the ST and PT condition. The analyzed latency range from 500 to 800 ms is shown as grey shaded area. Pronounced left parietal old/new effects to items of the self-generate condition were found, irrespectively to their target status (targets in the ST condition, nontargets in the PT condition); in contrast, items of the perceive condition elicited a significant left parietal old/new effect only when they were targets.

The old/new effects from 500 to 800 ms (Fig. 4) were topographically not confined to left-parietal electrode sites, but also observed at midfrontal electrodes. Overall, the pattern of old/new effects from 500 to 800 ms at the midfrontal electrode FCz and left-parietal electrode P5 was very similar. The only remarkable exception was that at FCz the ERP responses to nontargets in the ST condition were even more negative than to new items ($t_{31}=2.641$, $p=0.013$). Since differential early midfrontal and late left-parietal old/new effects were found in the PT condition (Table 4), with similar old/new effect for targets and nontargets in the early time window but larger late parietal old/new effects to nontargets than to targets, we further analyzed the effects in two ANOVAs: First, we contrasted the old/new effects from 500 to 800 ms in the PT condition between the midfrontal and left-parietal electrodes by an ANOVA with STIMULUS and ELECTRODE (FCz, P5) as within-subject factors. This analysis did not reveal a significant interaction between the two factors ($F_{2,\,62}=0.001$, n.s.). Thus, in the 500–800 ms time window, the parietal and midfrontal old/new effects could not be dissociated topographically. Second, we compared the early and late old/new effects in the PT condition by an ANOVA with STIMULUS and TIME (400–500 ms vs. 500–800 ms) as within-subject factors. This ANOVA revealed significant interactions between the two factors at both FCz ($F_{2,\,62}=3.666$, $p=0.031$) and P5 ($F_{2,\,62}=11.383$, $p<0.001$, $\varepsilon=0.807$). These interactions indicate that the old/new effects in the early and late time window varied systematically as a function of stimulus type.

To sum up the findings on the early midfrontal and late left-parietal old/new effect, we observed these old/new effects to all old items, except nontargets in the ST condition. Thus, when self-generated items were targeted, the two old/new effects were confined to targets. Their magnitude to self-generated items did not vary with target definition, while the effects to perceived items were significantly larger when these items were defined as targets. Most importantly, when perceived items were targeted, the magnitude of the early midfrontal old/new effect did not differ between targets and nontargets, but the parietal old/new effect was stronger for nontargets than for targets.

Frontal old/new effect (700–1000 ms): The occurrence of a frontal old/new effect in the time window from 500 to 800 ms was unexpected (Fig. 4). Visual inspection of the old/new effect showed that this effect had its maximum around electrode F1 and exhibited a biphasic wave form. In an exploratory analysis, a time window from 700 to 1000 ms was chosen in order to cover the second phase of the frontal effect and to test its modulation by CONDITION and STIMULUS. The ANOVA revealed a significant CONDITION × STIMULUS interaction (Table 3). Separate ANOVAs for each condition revealed that the effect was observed only to self-generated items: Thus, in the ST condition, frontal ERPs were more positive for targets than for nontargets. In the PT condition, frontal ERPs were more positive for nontargets than for targets and new items (Fig. 5, Table 4).

Late posterior negativity (LPN) (900–1500 ms): The analysis of the amplitudes at electrode POz revealed significant main effects of STIMULUS and CONDITION, but no interaction effect (Table 3). ERPs to targets and nontargets were more negative than to new items and ERPs were more negative in the PT condition than in the ST condition (Fig. 6). Thus, significant LPNs were observed for targets and nontargets in both conditions, with no difference between targets and nontargets.

Late frontal old/new effect (900–1500 ms): Analyzing the effects of STIMULUS and CONDITION on the right frontal old/new effect revealed no significant effects (Table 3), when data recorded at electrode F6 were entered. Thus, this analysis gave no evidence for a right-frontal old/new effect. As evident by visual inspection of the topographic maps in Fig. 6, any late frontal effect was virtually absent for all old items but nontargets in the PT condition. For the latter items, the late frontal old/new effect was more symmetrically distributed and had its maximum at electrodes F1 and Fz. A post-hoc analysis of Fz data in the late time window (900–1500 ms) confirmed the visual impression and showed that there was indeed

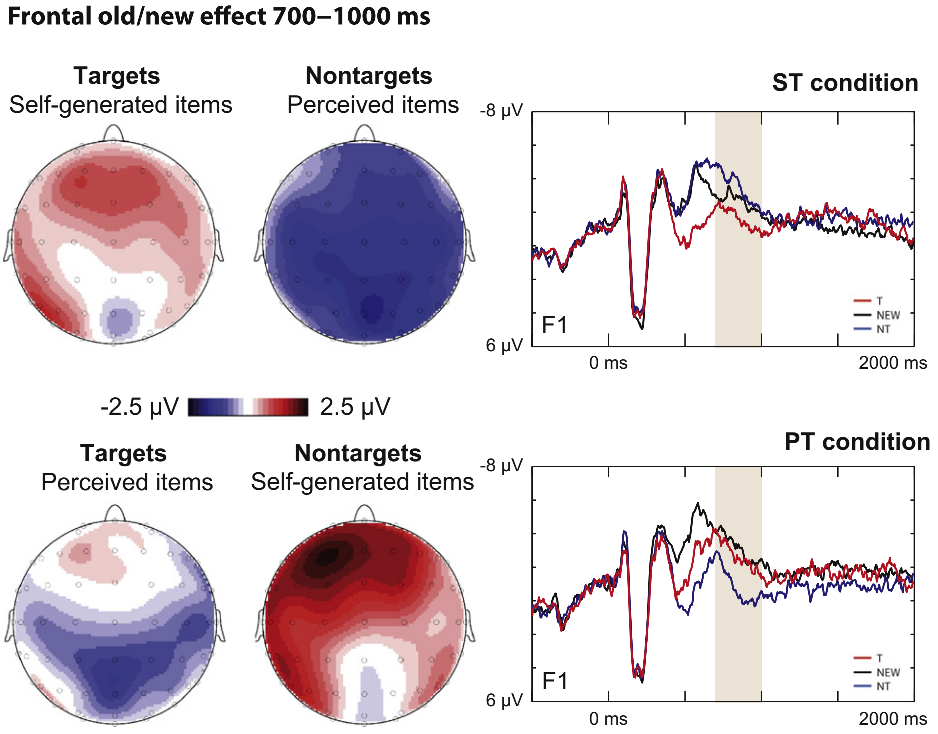

Fig. 5. The frontal old/new effect for targets and nontargets in the two test conditions, for the 700–1000 ms latency range: On the left, difference maps are displayed from the top view. On the right, ERPs to targets, nontargets and new items at electrode F1 are shown, separately for the ST and PT condition. The analyzed latency range from 700 to 1000 ms is shown as grey shaded area. A frontal effect in this latency range was observed for generated items, both when defined as targets and nontargets.

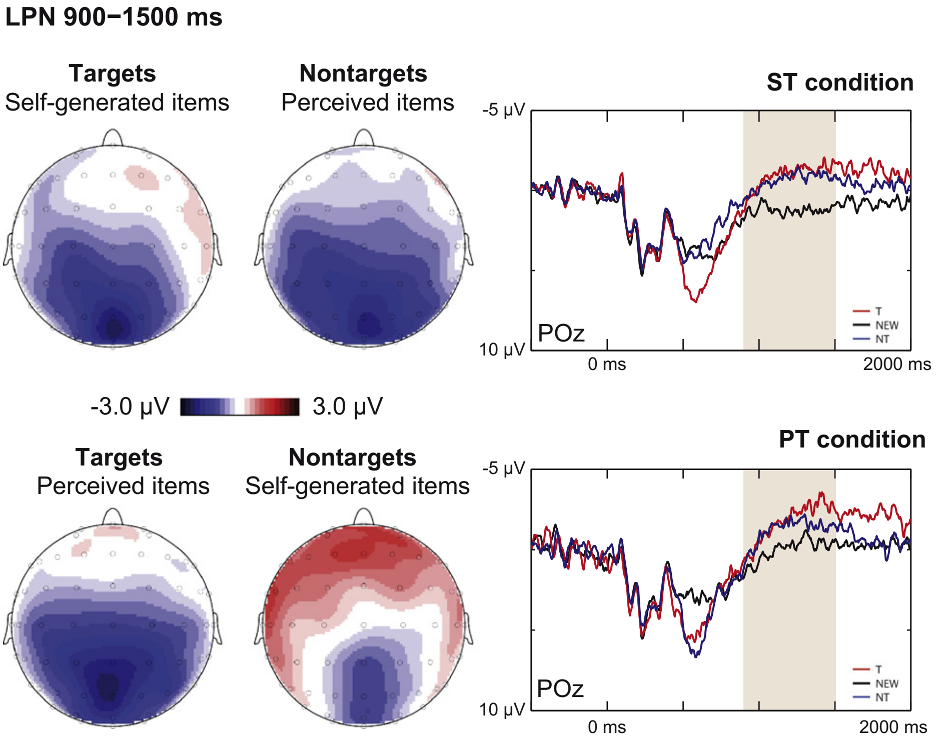

Fig. 6. The LPN old/new effects for targets and nontargets in the two test conditions, for the 900–1500 ms latency range: ERPs are shown for the electrode POz where the LPN effect was maximal. The analyzed latency range is shown as grey shaded area. In both test conditions, the LPN was observed in response to old items. The figure also shows that a late frontal effect was present only in response to nontargets in the PT condition.

a late frontal old/new effect, confined to nontargets in the PT condition (Tables 3 and 4).

3.3.3. Relationship between strategic retrieval, retrieval accuracy, and retrieval orientation

Strategic retrieval in form of a left-parietal old/new effect in response to nontargets was observed in the PT condition, but not in the ST condition. In the final step of analysis, we tested if this ERP measure of nontarget retrieval co-varied with other ERP and behavioral measures of retrieval accuracy in order to seek empirical support for models of nontarget retrieval proposed by Herron and Rugg (2003b) and Rosburg et al. (2011b).

Strategic retrieval and retrieval accuracy for target and nontarget information: The retrieval accuracy for target information in the PT condition was presumed to be reflected in the left-parietal old/new effect to perceived items as targets (because the nontarget retrieval might have affected the Pr_{PT} value); the accessibility of nontarget information in the PT condition was assumed to be reflected in the Pr_{ST} value (because in this condition nontarget retrieval played a negligible role, as revealed by the absent left parietal old/new effect) and in the left-parietal old/new effect to self-generated items as targets.

The left-parietal old/new effect to perceived items as targets correlated positively with the old/new effect to nontargets in the PT condition ($r=0.402$, $p=0.025$, $n=31$). In other words, contrary to what might be expected from the model of Herron and Rugg (2003b), increased levels of target recollection were associated with increased levels of nontarget recollection in this condition. In contrast, in accordance with our model that the retrieval of nontarget information is promoted by its accessibility, participants with high levels of recollection for self-generated items as targets showed also high levels of recollection when these items were defined as nontargets. In fact, the left-parietal old/new effect to self-generated items as targets correlated positively with the old/new effect to nontargets in the PT condition ($r=0.642$, $p<0.001$). No such correlation was found for the left-parietal old/new effects to perceived items as targets and nontargets ($r=0.150$, n.s.). The notion that the easy accessibility supports nontarget retrieval was, however, not further supported by a significant correlation between the behavioral measure of nontarget accuracy (Pr_{ST}) and the parietal nontarget old/new effect ($r=0.067$, n.s.).

Strategic retrieval & retrieval orientation: As outlined by Herron and Rugg (2003b), strategic recollection might be achieved by adopting retrieval orientation. Higher levels of retrieval orientation might then be associated with higher levels of target retrieval (prioritization of target information) and might be inversely related to nontarget retrieval, as reflected in the left-parietal old/new effect to each kind of items. Correlating the ERP retrieval orientation effect (600–800 ms) with the left-parietal old/new effects in the PT condition revealed, however, no significant results. Thus, we did not reveal an association between the ERP measures of retrieval orientation and strategic recollection.

4. Discussion

We aimed to investigate neural correlates of retrieval orientation and strategic retrieval in reality monitoring. In a memory exclusion test, participants had to identify words that were generated during study ('self-generated') or that were identified as sentence subjects ('perceived'). Participants' retrieval accuracy was better for self-generated material. Processing of new items (the retrieval orientation effect) varied with the test condition: ERPs to new items were more positive over midline electrodes between 600 and 800 ms when self-generated items were targeted. ERP old/new effects varied as a function of studied material and test condition: Self-generated items elicited an early mid-frontal old/new effect (400–500 ms) in both test conditions, thus irrespectively of their target status, while the effect was observed for perceived items only when they were defined as targets. A left-parietal old/new effect (500–800 ms) was obtained to all old items, except nontargets in the ST condition, and it was stronger for self-generated items than for perceived items, even when perceived items were defined as targets. A later frontal old/new effect (700–1000 ms) was observed in response to self-generated items, but not to perceived items. In contrast, the LPN as another prominent old/new effect did not vary between conditions and between targets vs. nontargets. Surprisingly, a late right-frontal old/new effect (900–1500 ms) was observed in neither test condition. Instead, a late, more medially distributed frontal old/new effect was found, but only in response to nontargets in the PT condition. In the following, we discuss the findings in more detail.

4.1. Behavioral effects

In our previous study, retrieval accuracy was better for object words followed by a picture of the denoted object than for object words for which participants had to create a mental image (Rosburg et al., 2011a). Since retrieval accuracy was found to modulate the retrieval orientation effect, we sought to design a new study in which retrieval accuracy was better for generated material than for perceived material. In other words, we sought to create a test design in which participants showed a typical generation effect (Slamecka & Graf, 1978). This attempt was successful. Our participants exhibited a retrieval advantage for the self-generated material, with more accurate and faster retrieval of self-generated words than of perceived words, similar as in previous studies using other verbal generation tasks (Leynes et al., 2005; Nieznański, 2011; Riefer, Chien, & Reimer, 2007; Vannest et al., 2012).

The relatively low retrieval accuracy for perceived items resulted in a considerable number of subjects ($n=12$) who had to be excluded from the analysis due to their poor performance. Yet, when our sample was divided into high vs. low performers in the PT condition, the retrieval accuracy of low performers was clearly above chance ($t_{15}=5.047$, $p<0.001$). The relatively poor performance in this condition might be explained by the fact that participants encountered a substantial number of object words during study, namely not just the study items but also the nouns used as sentence objects. Furthermore, participants might have remembered more the meaning of the sentences rather than their exact wording. In the ST condition, participants are confronted with the same difficulties, but here memory performance benefitted from the generation effect. Although the presentation of study words in a sentence context might have lowered memory accuracy to some extent, the experimental design had the advantage that the two study conditions shared important task elements: In both, participants had to read the sentence containing the study item and to name the study item once it was identified, leaving the origin of information (self-generated vs. perceived) as the primary difference.

4.2. Retrieval orientation

In our previous study (Rosburg et al., 2011a), ERPs to new items were more positive at frontal electrode sites between 600 and 1100 ms when self-generated items were targeted than when perceived items were targeted. We interpreted this impact of test condition on the processing of new items as a retrieval orientation effect. However, we also found that the retrieval accuracy varied between the two test conditions and that the described ERP effect was modulated by relative task difficulty, i.e. it was larger for participants with low memory performance for imagined items. Thus, the ERP effect could have been the consequence of the higher level of retrieval effort in the latter test condition rather than being genuinely associated with retrieval orientation for imagined events. Following this argument, in the current study one would have expected to find a reversed pattern with more positive ERPs to new items in the more effort demanding PT condition. However, this was not the case. Instead, we revealed again more positive ERPs to new items when self-generated items were targeted than when perceived items were targeted, which supports our interpretation that the observed positivity to new items when self-generated information is targeted is a correlate of a retrieval orientation. The ERP effect in the present study and in the Rosburg et al. (2011a) study is thus observed irrespective of retrieval difficulty, and may therefore be considered a correlate of a retrieval orientation that participants engage in order to optimize their retrieval of self-generated information from a previous event.

The relation between retrieval orientation and retrieval accuracy is yet not fully resolved, as summarized previously in detail (Rosburg et al., 2011a): Effective usage of retrieval cues, as reflected in large ERP retrieval orientation effects, has been regarded as beneficial for retrieval processes and was associated with better retrieval accuracy (Bridger, Herron, Elward, & Wilding, 2009; Bridger & Mecklinger, 2012). Others claimed no interactions between ERP correlates of retrieval orientation and retrieval accuracy (Robb & Rugg, 2002; Morcom & Rugg, 2004). Finally, we have argued in favor of a compensatory effect, i.e. retrieval orientation might be more strongly engaged with increasing relative task difficulty for self-generated items (Rosburg et al., 2011a; see also Dzulkifli, Sharpe, & Wilding, 2004).

In the current study, we did not replicate our previous finding of a negative correlation between relative retrieval accuracy ($\Delta\text{Pr}=\text{Pr}_{ST}-\text{Pr}_{PT}$) and the ERP retrieval orientation effect (Rosburg et al., 2011a). However, none of our current participants retrieved perceived items better than self-generated items, and in 30/32 participants, a relative retrieval accuracy $\Delta\text{Pr}\geq 0.2$ was observed. Thus, retrieval effort was always much higher in the PT condition. A tentative explanation for current null finding is that these high levels of retrieval effort in the PT condition might have created a ceiling effect and hindered the observation of a modulation of the ERP retrieval orientation effect by retrieval accuracy.

Even though the retrieval orientation effects in the present and our pervious study were similar in polarity and in their temporal characteristics, their topographic distribution differed between the studies. In our previous study, the retrieval orientation effect was found exclusively at frontal electrode sites, while the topography of the currently observed effect was less clear-cut and extended to posterior electrode sites. However, the topography of a retrieval orientation effect can be assumed to depend on which retrieval conditions are contrasted, as outlined previously in more detail (Rosburg et al., 2011a), because retrieval orientation reflects the different ways in which memory traces are probed for different kinds of information (Johnson, Kounios, & Nolde, 1997). It might enhance the processing of retrieval cues (cue bias) or might directly act on memory representations and modulate their accessibility (target bias) (Anderson & Bjork, 1994; Dzulkifli & Wilding, 2005; Mecklinger, 2010). However, here, we did not reveal support for the hypothesis that retrieval orientation supports target bias: The left-parietal effects for targets and nontargets did not show any significant correlation with the ERP retrieval orientation effect.

Although both of our studies directly compared the retrieval of self-generated and perceived material, there are also considerable differences between the studies. Our previous study contrasted the processing of new items when object words in association with imagined or perceived pictorial information were targeted (Rosburg et al., 2011a) and the presented object pictures were of high perceptual richness (Rossion & Pourtois, 2004). Here, we contrasted the processing of new items when object words were targeted that were either deduced from the semantic context (self-generated items) or identified from the grammatical structure (perceived items). Focusing on the grammatical structure might have hindered the participants from visualizing the verbal contents and, given this, perceived items were presumably only poorly associated with pictorial information. Thus, the importance of semantic information, the richness of pictorial information, and the cognitive operations for generating information have varied between the two studies. Taking these differences into account, one would not predict highly similar topographies of ERP retrieval orientation effects.

4.3. Old/new effects

4.3.1. Early midfrontal old/new effect

According to dual-process models of recognition memory, the early midfrontal old/new effect is believed to reflect familiarity related processes (Rugg & Curran, 2007). Familiarity is often operationally defined as information that supports recognition in the absence of recollection. In the current study, an early midfrontal old/new effect was observed in response to items of the self-generate condition independently of target definition, but in response to perceived items only when they were defined as targets. This finding suggests that familiarity can be modulated by top-down processes: In situations as the PT condition, in which target memory representations are weak and difficult to retrieve, participants can adjust their retrieval orientation by giving more weight to target information and this leads to a familiarity signal for perceived items in this test condition. This interpretation is consistent with the conclusion drawn from recent studies (Groh-Bordin, Zimmer, & Mecklinger, 2005; Ecker & Zimmer, 2009), saying that strategic retrieval processes can modulate familiarity-related processes, as reflected in the early midfrontal old/new effect.

In the study by Ecker and Zimmer (2009), participants saw object pictures during the study phase. Subsequently, participants had to make old/new decisions for studied pictures, different category exemplars, or new items. Pending on the test condition, the different category exemplars had to be accepted as old item (general test condition) or to be rejected as new (specific test condition). The basic idea behind that study was that in the specific test condition participants should focus on perceptual features of the presented items (because only this would allow an identification and rejection of different category exemplars), while in the general test condition participants should focus on conceptual (categorical) information. Indeed, Ecker and Zimmer (2009) could show that an early midfrontal old/new effect was elicited by different exemplars in the general task but not in the specific task. Their study was, to our knowledge the first and up-to-now, only study showing that the early midfrontal old/new effect depends partially on subjects' retrieval orientation. However, already a previous study showed that familiarity can depend on the participants' strategic retrieval processing: An early old/new effect was elicited only when participants performed an explicit memory task, that required the adaptation of an episodic retrieval mode, but not when they performed an implicit task (Groh-Bordin et al., 2005).

The interpretation of the early midfrontal old/new effect as familiarity-related signal has not remained unchallenged. Paller, Voss, and Boehm (2007) referred the effect to a form of implicit memory known as conceptual priming. Although the current study did not explicitly address these conflicting views on the functional interpretation of the early midfrontal old/new effect, the presence of the effect to items of the perceive condition when these items were targeted and its absence when these items were not targeted is difficult to reconcile with the view that the early midfrontal old/new effect reflects conceptual priming. The findings of Groh-Bordin et al. (2005) and Ecker and Zimmer (2009) cast similar doubts on such an interpretation. It should be noted, however, that ERP studies including our previous study (Rosburg et al., 2011b) often show that the midfrontal old/new effect does not vary with target definition. Presumably, a modulation of the early midfrontal old/new effect by top down processes such as retrieval mode or orientation is more likely in situations in which the crucial item information is only weakly encoded.

4.3.2. Strategic retrieval (left-parietal old/new effect to nontargets)

Similar to our previous study, we revealed a left-parietal old/new effect to nontargets only in the more difficult test condition. Usually the parietal old/new effect to nontargets is smaller than the effect to targets or it has the same size (e.g. Herron & Rugg, 2003a; 2003b; Wilding et al., 2005; Fraser, Bridson, & Wilding, 2007; Rosburg et al., 2011b). Here, in the PT condition, the left-parietal old/new effect to nontargets surmounted the target old/new effect. For self-generated items as targets and nontargets, the left-parietal old/new effect had a similar size, but the response times and later old/new effects varied with target definition: When self-generated items were nontargets, response times were nearly 300 ms longer than when they were targets ($t_{31}=9.354$, $p<0.001$). Furthermore, only when self-generated items were nontargets, a later frontal old/new effect (900–1500 ms) was observed. Thus, the processing of self-generated items as targets and nontargets varied after recollection (500–800 ms) took place.

Our current finding is in line with the concept of Herron and Rugg (2003b) that nontarget retrieval is governed by the retrieval difficulty of target information: Nontarget retrieval occurred only in the more difficult test condition. We previously extended the concept of Herron and Rugg (2003b) by proposing that in some situations the easy accessibility of nontarget information promotes its retrieval rather than the difficulty of retrieving target information (Rosburg et al., 2011b). Our argumentation was based on the finding that the left-parietal old/new effect for nontargets in the more difficult test condition was correlated with the retrieval accuracy in both test conditions.

In the current study, no significant correlation between the left-parietal old/new effect for nontargets in the PT condition and the behavioral measure of retrieval accuracy for self-generated items ($\mathrm{Pr}_{\mathrm{ST}}$) was revealed. However, when correlating the left parietal old/new effects between conditions and targets/nontargets, we found in the PT condition that the old/new effects to targets correlated positively with old/new effects to nontargets. Thus, participants showed less evidence for nontarget retrieval when they had small left-parietal old/new effect to targets. This is contrary to what might be expected from the hypothesis of Herron and Rugg (2003b). Second, the far best predictor for the left-parietal old/new effect to the self-generated items as nontargets was the left-parietal old/new effect to self-generated items as targets. Since the left-parietal old/new effect has been associated with encoding depth (Rugg et al., 1998) and deeper encoding should ease retrieval, we consider the observed correlation between the left-parietal old/new effects to self-generated items as targets and nontargets as further evidence that easy accessibility of nontarget information promotes its retrieval. It should, however, be acknowledged that other instances of nontarget retrieval can be explained better by the account of Herron and Rugg (2003b). In the studies of Dzulkifli and Wilding (2005), Dzulkifli et al. (2006), and Wilding et al. (2005) nontarget retrieval was shown to occur when target accuracy was lowered by increasing the task difficulty (by using longer study lists or longer delays between study and test). With increased task difficulty, the accessibility of nontarget information in all likelihood decreased as well. Thus, in these studies nontarget retrieval was probably governed by the retrieval difficulty of target information, as proposed by Herron and Rugg (2003b), and not by the accessibility of nontarget information.

The current study did not reveal any association between strategic recollection and the ERP retrieval orientation effect. Accordingly, the present results offer no support for the view that strategic retrieval can be conceptualized as the consequence of adopting retrieval orientation, as e.g. discussed by Herron and Rugg (2003b) or Dzulkifli and Wilding (2005). In contrast, the current findings clearly question the view that the likelihood of nontarget retrieval depends on the similarity between target and nontarget information (Herron & Wilding, 2005): Nontarget retrieval occurred when perceived items were targeted but not when self-generated items were targeted. This asymmetry of nontarget retrieval between test conditions was found, even though the similarity between target and nontarget information did not vary between them. A similar finding was obtained in our previous study (Rosburg et al., 2011b). Directly addressing this issue, Evans, Wilding, Hibbs, and Herron (2010) found that the left parietal old/new effects to nontargets were not influenced by the similarity of target and nontarget information either.

Nontarget retrieval was observed for perceived items in our previous study (Rosburg et al., 2011b) and for self-generated items in the current study. Thus, nontarget retrieval in a reality monitoring task does obviously not depend on the source of information (external vs. internal), but possibly on its accessibility. Coming back to the example of the academic's nightmare of a disgraceful conference presentation, it is not unlikely that in such a situation the academic recollects his most recent conference presentation that can probably easily be retrieved due to the recency, self-relevance, and distinctiveness of such an episode. Thus, he recollects not only the dream content, but also what he is rather sure to be a real-life episode. These memories hopefully include pleasant feelings of success and triumph, refuting the dream's content as memory from real life. (The tricky thing about dreams is that they refer sometimes to real life experiences that are rehearsed and distorted during dreaming. The academic might wake-up and know that he just had a dream, because he remembers typical dream-like elements, such as having been naked at the speaker's desk. However, even with this awareness, there is still the disturbing possibility that the core experience of the dream, having a presentation disaster on a conference, actually took place in real life.)

To sum up our ERP findings on nontarget retrieval, nontarget retrieval was observed only for self-generated items in the more difficult PT condition. Contrary to what can be expected from the hypothesis of Herron and Rugg (2003b), the left-parietal old/new effect to nontargets in this condition increased with increasing old/new effects to perceived targets. The left-parietal old/new effect to self-generated items as nontargets was predicted best by the size of old/new effect to this kind of items as targets. This might be interpreted in favor of our hypothesis (Rosburg et al., 2011b) that the easy accessibility of nontarget information increases the likelihood that nontarget information is actually retrieved. Our studies furthermore show that nontarget retrieval in reality monitoring does not depend on the source of information.

4.3.3. *Frontal old/new effect*

A later frontal old/new effect (700–1000 ms) was observed only in response to self-generated items, but not to perceived items. The effect differed from the temporally overlapping parietal and sustained frontal old/new effects. Such a frontal old/new effect has not been described in the literature, but some studies showed that the distribution of the electrophysiological correlates of recollection for verbal material varies with the study conditions. Johnson, Minton, and Rugg (2008) compared the old/new effects of words that were either studied by generating sentences that incorporated them or by imagining the study items within superimposed scenic pictures. Recollection related old/new effects for words of the self-generate condition (starting after 500 ms) were characterized by a more anterior distribution than those of the scene condition. In a recent study of Leynes (2012), the late old/new effect (600–900 ms) for generated items was frontally distributed, as well (see also Johansson et al., 2002). One might speculate that this late frontal old/new effect reflects the reinstatement of word generation processes performed exclusively for self-generate items at study. The left inferior frontal gyrus represents a core region for semantic selection demands in word generation (Thompson-Schill, D'Esposito, & Kan, 1999; Thompson-Schill et al., 1998). Furthermore, Johnson and Rugg (2007) showed that the encoding-related activity and recollection-related activity for generated items overlapped in the left medial frontal gyrus, which supported the view that recollection involves the reinstatement of processes or representations that were active when the episode was encoded. Yet, further studies are warranted to elucidate whether the here observed frontally distributed old/new effect for generated verbal material is actually associated with activation of these (left inferior or left medial) frontal brain regions.

4.3.4. *LPN*

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). It has been proposed that the amount of contextual information potentially available for the reconstruction of the study episode represents one factor influencing the LPN amplitude (Johansson & Mecklinger, 2003; Mecklinger, Johansson, Parra, & Hanslmayr, 2007). In both of our study conditions, items were presented in the context of a sentence, but generating items may include more cognitive operations and, thus, provide more contextual information than identifying the subject of a sentence. Consequently, we had expected a larger LPN in response to items of the self-generate condition. However, the LPN amplitude did not vary systematically between the two test conditions and between targets and nontargets.

There are two possible explanations for this lack of significant differences. One possibility is that the amount of contextual information for self-generated items was indeed larger, but as these items were easily recoverable upon presentation of the test cues the need for continued evaluation for these items was also lower. These two opposing effects on the LPN amplitude might have canceled out each other, leading to the null finding. However, it should be noted that task difficulty (as potential major factor affecting the need for a continued evaluation) has apparently not a crucial influence on the LPN amplitude (Sprondel et al., 2012). As an alternative explanation, we propose that the amount of contextual information actually used for the reconstruction of the study episode rather than the amount of contextual information potentially available for it influences the LPN amplitude. Thus, if the critical source information is binary (e.g. words shown at the top or bottom of the screen), the amount of the available context information necessarily limits the amount of context information that can be used for the reconstruction of study episodes at retrieval. If source information consists of several elements (e.g. reading a sentence containing the study item and processing its semantic/grammatical features), one cannot predict on the basis of the conducted study task which portion of the available contextual information will actually be used by the rememberer when reconstructing the study episode.

4.3.5. Late right frontal old/new effect

Somewhat surprisingly, we observed no significant right frontal old/new effect in the current study. However, the functional role of this effect is yet disputed (for a recent discussion see Cruse & Wilding, 2009; Hayama, Johnson, & Rugg, 2008). Consequently, the conditions under which such an effect might be observed or might not be observed need yet to be determined. Other ERP studies reported sometimes missing late right frontal old/new effects, as well (e.g. Leynes et al., 2005 in their reality monitoring experiment).

Instead of a right late frontal old/new effect, a late, more medially distributed late frontal old/new effect (900–1500 ms) was found for nontargets in the PT condition only. A selective late frontal old/new effect after nontarget retrieval has so far not been reported. So why does the frontal effect appear under the current experimental conditions? In the PT condition, we can firmly assume that participants actually targeted perceived items because we observed not only a retrieval orientation ERP effect, but also differential early midfrontal old/new effects for perceived items as targets and nontargets and differential response times for self-generated as targets and nontargets. As outlined, we have further argued that nontarget retrieval occurs when the nontarget information can easily be accessed (Rosburg et al., 2011b), presumably in a form of incidental retrieval (Richardson-Klavehn & Gardiner, 1995). This might result in conflicts with the current task demands, i.e. the instructed target definition, in particular when the nontarget information is much more vivid than the target information, such as in the current experiment. In this situation, participants might try to re-orient their attention back towards the targeted information because the weakly encoded perceived items do neither elicit a familiarity-related signal automatically nor is this perceived information incidentally retrieved. Thus, the late frontal effect following nontargets in the PT condition could reflect the reorientation back to the targeted perceived items or, alternatively, response conflict processes, because participants have to reject the more vividly remembered self-generated items as nontargets.

On the basis of the current data, it is difficult to advocate between the two alternative explanations for the late frontal old/new effect. Response conflict processes presumably contributed to the observed increased reaction times for self-generated items as nontargets, as compared to self-generated items as targets. However, the increase in reaction times ($RT_{Nontarget\_PT} - RT_{Target\_ST}$) did not correlate with the magnitude of the late frontal old/new effect to nontargets in the PT condition at Fz ($r = -0.045$, n.s.). In contrast, if the late frontal old/new effect to nontargets reflected reorientation back to the targeted material, its magnitude should correlate with the magnitude of the retrieval orientation effect. Indeed, we found that the two ERP effects were correlated ($r = 0.365$, $p = 0.040$). Thus, effective reorientation after nontarget retrieval might have led to larger retrieval orientation effects. This finding tentatively supports the interpretation that the late frontal old/new effect to nontargets in the PT condition reflects reorientation processes.

5. Conclusions

In the current study, retrieval orientation affected not only the processing of new items but also had an impact on whether an early midfrontal old/new effect was elicited by less well encoded items of the perceive condition, suggesting that retrieval orientation can modulate the accessibility of memory representations. Furthermore, we obtained new evidence that nontarget retrieval occurs when this information can easily be accessed, as previously proposed (Rosburg et al., 2011b). In extension to our previous findings, a late frontal old/new effect (900–1500 ms) was exclusively observed after nontarget retrieval, possibly reflecting a reorientation back to the target information.

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