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The late posterior negativity in episodic memory: A correlate of stimulus retrieval?

Kathrin Sommer*, Salvatore Vita, Vilfredo De Pascalis

Department of Psychology, La Sapienza University of Rome, Italy

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ABSTRACT

We investigated whether the late posterior negativity (LPN) is a component linked to stimulus retrieval or rather to complex, higher-order stimulus evaluation processes or response preparation processes. Participants performed three separate tasks across separate sessions: an encoding task, a memory recognition task, and a visual discrimination task. In the visual discrimination task, the difficulty of stimulus evaluation was manipulated via stimuli varying in complexity (easy vs. moderately difficult) and duration of stimulus presentation (short vs. long). Three indices of the LPN peak were examined: amplitude, latency, and width. The LPN was present in all three tasks, with maximum amplitudes at occipital sites. Results of the visual discrimination task showed that the LPN amplitude is modulated by task difficulty. No latency differences were observed between short and long presentations, suggesting that the LPN is not related to response preparation. Consequently, we compared the LPN associated with short presentations of easy and difficult stimuli with the LPN of the encoding and memory task. The LPN amplitude was more negative in the memory task compared to the other tasks. Latency and width of the LPN were modulated by stimulus complexity, with increased latency and width in the encoding and memory task relative to the visual discrimination task. Overall, these findings suggest that the LPN is not a component linked to stimulus retrieval and response preparation, but rather to complex, higher-order stimulus evaluation processes, which are modulated by task difficulty.

1. Introduction

Various studies examining event-related potentials (ERP) during memory retrieval have reported a late posterior negativity component (LPN, 800–1200 ms), which has frequently been observed in source memory tasks but also in item memory tasks. In item memory tasks, the participant is required to make simple yes/no recognition judgments with regard to the presented material, whereas in source memory tasks the participant is required to recognize the presented stimulus as old or new and the context (e.g., background color) in which the stimulus was presented. The LPN is maximal at parietal-occipital sites, it has been found to be more negative in response to old items than correctly rejected new items, and the LPN is often accompanied with a frontal positive slow wave (Johansson & Mecklinger, 2003). The functionality of the LPN is not clear, but it has been suggested that the LPN reflects action monitoring processes (e.g., Johansson and Mecklinger, 2003), response-related processes (e.g., Wilding & Rugg, 1997), and retrieval processes, i.e. reconstruction and evaluation processes (e.g., Johansson & Mecklinger, 2003; Mecklinger, Rosburg, & Johansson, 2016). The reader is referred to Johansson and Mecklinger (2003) and Mecklinger et al. (2016) for extensive reviews on the functionality of the LPN in episodic memory studies.

In item recognition tasks, the LPN has been hypothesized to reflect the involvement in action monitoring (including error-detection and conflict monitoring) in relation to the response. The LPN has been seldomly observed in mere item recognition tasks studies, but rather in item memory tasks that manipulated response selection demands or that employed a false recognition paradigm, in which false alarms were associated with prolonged reaction times (Johansson & Mecklinger, 2003). It has been assumed that when the experimental procedure gives rise to false alarms, the LPN may be linked to action monitoring processes due to response conflict (e.g., Curran, DeBuse, & Leynes, 2007; de Chastelaine, Friedman, & Cycowicz, 2007; Herron, 2007; Nessler, Mecklinger, & Penney, 2001; Nessler & Mecklinger, 2003). Specifically, the results of previous studies suggest that action monitoring processes contribute to the LPN when the stimulus-locked LPN is accompanied by response-locked error-related negativity (Johansson & Mecklinger, 2003; Mecklinger et al., 2016).

It has also been suggested that the LPN is related to response-related processes, because of observed associations between reaction time (RT)

* Corresponding author at: Department of Psychology, La Sapienza University of Rome, Via dei Marsi 78, 00185 Rome, Italy.
E-mail address: kathrin.sommer@uniroma1.it (K. Sommer).

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and LPN amplitude (e.g. Wilding & Rugg, 1997). Specifically, Wilding and Rugg (1997) observed that longer RTs were associated with increased LPN amplitudes and the correlations were strongest for false alarms, suggesting that the LPN reflects response-related processes rather than mnemonic processes. Correspondingly, additional support for a response preparation account of the LPN was obtained by the study by Kuo and Van Petten (2006). In this study, longer RTs associated with old items, compared to new items, were related to enhanced LPN amplitudes. In addition, the LPN was larger contralateral to the hand used to indicate recognition judgments for old items, which led the authors to suggest that the LPN reflects an extended Readiness Potential. Nevertheless, other studies failed to show RT differences between conditions that elicited an LPN and those that did not (e.g., Cycowicz, Friedman, & Snodgrass, 2001; Leynes & Bink, 2002; Rugg, Schloerscheidt, & Mark, 1998; Wilding & Rugg, 1996).

In source memory tasks, the LPN has been hypothesized to be involved in the reconstruction of the study episode by retrieving and evaluating attribute conjunctions, such as item-source and item-context associations (Johansson & Mecklinger, 2003; Mecklinger et al., 2016). It has been observed that the LPN in source memory tasks is not affected by the correctness of source judgments but rather by the amount of information that can be retrieved and with the specificity with which memory is searched (e.g., Leynes, Grey, & Crawford, 2006; Leynes & Kakadia, 2013; Mecklinger et al., 2016). That is, the LPN is smaller when contextual attributes are retrieved effortlessly and thus the amount of retrievable information is restricted (Mecklinger, Johansson, Parra, & Hanslmayr, 2007).

Studies that confronted the LPN in item and source memory tasks observed enhanced LPN amplitudes in source memory tasks compared to item memory tasks (Cycowicz et al., 2001; Friedman, Cycowicz, & Bersick, 2005; Senkfor & Van Petten, 1998). These findings suggest that the LPN may rather be modulated by task difficulty. This notion is further supported by the observation of better behavioral performance during in the item task relative to the source memory task (Cycowicz et al., 2001; Friedman et al., 2005), although other studies noted the contrary (Johansson, Stenberg, Lindgren, & Rosén, 2002) or no differences in recognition performance between tasks (Senkfor & Van Petten, 1998). The inconsistent results may be due to task differences as the study by Johansson et al. (2002) employed a reality monitoring (perceived vs. imagined) paradigm, whereas the source memory tasks of the other studies had participants recognize the background color or gender of the voice in which the stimulus was presented initially. Source memory studies examining the LPN under conditions of reality monitoring and internal source monitoring have repeatedly shown increased LPN amplitude for perceived than imagined stimuli, especially under conditions of internal source monitoring (Leynes, 2012; Leynes & Bink, 2002; Leynes & Kakadia, 2013). Further the LPN was found to be attenuated during reality monitoring relative to conditions of internal source monitoring. Since behavioral performance was found to be better during reality monitoring than during internal source monitoring, this again suggests that the LPN may be modulated by task difficulty. In concordance, a recent study has shown that when instructed to suppress a memory, this leads to a more negative LPN amplitude when the participant is confronted with a probe of the to be suppressed stimulus during another task (Hu, Bergström, Bodenhausen, & Rosenfeld, 2015). One study that directly examined the influence of task difficulty on the LPN failed to find differences in LPN amplitude between easy and more difficult task conditions (Sprondel, Hipp, & Mecklinger, 2012). However, this null-finding may be due to the fact that the behavioral performance did not differ between the easy and more difficult task condition, suggesting that the two conditions did not vary in task difficulty.

It is important to note that the LPN has mainly been observed and examined in memory studies. Few studies have reported potentials similar to the LPN in tasks that do not require explicit memory judgments. Studies that reported a negative potential similar to the LPN employed a negative priming task (e.g., Frings & Groh-Bordin, 2007) or they had participants perform evaluative judgments of music rules (Brattico, Jacobsen, De Baene, Glerean, & Tervaniemi, 2010) and artificial grammar (Schankin, Hagemann, Danner, & Hager, 2011). However, the LPN in these tasks often had an earlier onset, shorter duration, and a less restricted posterior topography as opposed to the LPN observed in memory tasks. Further, these studies are very heterogeneous, with the exception of the fact that all studies required the participants to make decisions based on what the participants had previously learned (e.g. grammar or music rules). Importantly, a recent study examined visual short-term memory by employing a delayed-match-to-sample task to examine the influence of cognitive load on the underlying ERP correlates (Yang, Wang, Yin, & Li, 2015). The results demonstrated an LPN during the initial study phase occurring prior to the memory test that was modulated by the load of the study task. That is, the LPN amplitude was more negative in the high-load than in the low-load condition. This observation is in line with our view that LPN may reflect general stimulus evaluation processes that are modulated by task difficulty.

The reviewed studies suggest an influence of action monitoring and retrieval processes (reconstruction and evaluation) on the LPN in episodic memory, while little support has been obtained for the involvement of response-related processes. The results of previous research further suggest an influence of task difficulty in the modulation of the LPN, although research is lacking that directly tested this hypothesis. Taking into account that few studies reported an LPN also in tasks that do not involve mnemonic processes, this suggests that the LPN reflects general stimulus evaluation processes that are modulated by task difficulty rather than memory specific processes. This view is further support by source memory studies showing that easily retrievable attributes elicit smaller LPN amplitudes compared to when attributes are not readily retrievable (Mecklinger et al., 2007, 2016). The aim of the current study was to address the hypothesis that the LPN reflects general stimulus evaluation processes which are modulated by task difficulty. In contrast to the P300 and late positive potential, which are two ERP components associated with later stages of stimulus processing, such as increased attention and stimulus evaluation (e.g., Olofsson, Nordin, Sequeira, & Polich, 2008), we assume that the LPN reflects a more complex, higher-order processing of the stimulus material (e.g., evaluative judgments). A secondary aim of the current study was to examine the contribution of response preparation processes in the modulation of the LPN. Participants performed three separate tasks (encoding task, item recognition task, visual discrimination task). In the visual discrimination task, the difficulty of stimulus evaluation was manipulated via stimuli varying in complexity (easy vs. moderately difficult) and duration of stimulus presentation (short vs. long). Half of the participants performed the memory task 15 min after the encoding task (recent delay group), while the other half of the participants performed the memory task one week after the encoding task (remote delay group). Behavioral performance was expected to be better for easy task conditions (encoding task, short and long presentations of easy figures) than for more difficult task conditions (memory task, short and long presentations of difficult figures). Regarding the visual discrimination task, we hypothesized better behavioral performance for difficult geometrical figures during long relative to short presentations, while behavioral performance was expected to be unaffected by the duration of stimulus presentation (short vs. long) for easy geometrical figures. In addition, behavioral performance in the memory task was expected to be better in the recent delay group compared to the remote delay group. Three indices of the LPN were examined: amplitude, latency, and width. In the present study, visual inspection of the ERP waveforms indicated variations in the width of the LPN across tasks. ERP components do not only vary in amplitude or latency, but also in the width of the ERP peak, and it has been suggested that the wavelength reflects the duration of cognitive processes (e.g., Gontier et al., 2009; Hu et al., 2011; Renault, Ragot, Lesevre & Remond, 1982).