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Neural correlates of source memory retrieval in young, middle-aged and elderly adults

Selene Cansino*, Evelia Hernández-Ramos, Patricia Trejo-Morales

Laboratory of NeuroCognition, Faculty of Psychology, National Autonomous University of Mexico, Mexico City, Mexico

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ABSTRACT

Event-related potentials (ERPs) were recorded in young (21–27 years old), middle-aged (50–57 years old) and older adults (70–77 years old) to determine whether the decline in source memory that occurs with advancing age coincides with contemporaneous neurophysiological changes. Source memory for the spatial location (quadrant on the screen) of images presented during encoding was examined. The images were shown in the center of the screen during the retrieval task. Retrieval success for source information was characterized by different scalp topographies at frontal electrode sites in young adults relative to middle-aged and older adults. The right frontal effect during unsuccessful retrieval attempts showed amplitude and latency differences across age groups and was related to the ability to discriminate between old and new images only in young adults. These results suggest that the neural correlates of the retrieval success and attempt were affected by age and these effects were present by middle-age.

1. Introduction

The ability to remember the spatio-temporal context of our own experiences declines with advancing age (Spencer and Raz, 1995). This is especially true when the information must be retrieved from episodic memory storage through re-experiencing, either mentally or externally, the event to which the specific contextual information is related, without any support from the environment. The retrieval of the event and its context involves multiple mechanisms that may be differentially affected in elderly adults. The present study focused on two of these retrieval mechanisms: *retrieval success* and *retrieval attempt*. The *retrieval success* involves the 'autonoetic' experience of the past and consists of successfully recovering episodic information during a retrieval attempt (Rugg and Henson, 2002), whereas the *retrieval attempt* includes all of the control processes engaged in the attempt to retrieve episodic information, such as search and monitoring that is independent of whether the information is successfully retrieved (Slotnick and Schacter, 2007; Schacter, 1996). In addition, the retrieval success and attempt are distinguished by the amount of information retrieved. High and low retrieval content is related to the retrieval success and the retrieval attempt without success, respectively (Slotnick and Schacter, 2007).

The neural activity associated with the retrieval success and the retrieval attempt for contextual information can be examined using source memory paradigms. These paradigms present each item in a specific context, and the participants are asked to retrieve the context related to each item. By examining the difference between correct and incorrect source responses, the neural activity associated with the conscious memory process of a successful retrieval attempt can be determined, whereas the difference between incorrect source responses and correct rejections (correct responses to new items) can be used to evaluate the neural activity related only to the retrieval attempt. Hereafter, the terms retrieval success and retrieval attempt will be used to refer to these two contrasting electrical brain activities, respectively. Moreover, correct source responses involve 'recollection' processes, i.e., the memory of an event accompanied by the context in which it took place (Aggleton and Brown, 1999; Mandler, 1980). In contrast, incorrect source responses do not correspond to 'familiarity' processes (Aggleton and Brown, 1999; Mandler, 1980). These processes refer to the

* Corresponding author at: Laboratorio de NeuroCognición, Facultad de Psicología, Universidad Nacional Autónoma de México, Avenida Ciudad Universitaria 3004, Colonia Copilco Universidad, Building D, 2nd floor, room 12, México D. F. 04510, Mexico. Tel.: +52 55 56 22 23 39; fax: +52 55 56 16 07 78.
E-mail address: selene@unam.mx (S. Cansino).

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memory for the event without the accompaniment of source or contextual information, and the failure to recall the source can only be confirmed for the 'critical' source information that was evaluated but not for other source information that may be retrieved during an incorrect response.

The previous event-related potentials (ERPs) studies in older adults using a source memory paradigm examined the neural correlates of retrieval success of contextual information by comparing correct and incorrect source responses (Schiltz et al., 2006; Trott et al., 1997, 1999), correct source responses with correct rejections (Li et al., 2004; Mark and Rugg, 1998; Swick et al., 2006) or correct recognition (hits including correct and incorrect source responses) with correct rejections (Duverne et al., 2009; Wegesin et al., 2002). However, few studies (Schiltz et al., 2006; Trott et al., 1997, 1999) evaluated the neural activity related only to the retrieval attempt, i.e., when participants fail to retrieve the source, because there are not always enough incorrect source responses. Insufficient incorrect source responses may be due to the source memory tasks employed in most of these studies (Duverne et al., 2009; Li et al., 2004; Mark and Rugg, 1998; Swick et al., 2006; Trott et al., 1997, 1999; Wegesin et al., 2002). These studies examined memory of two possible contexts. To maintain the source accuracy rates above chance using a two-choice task ($p = 0.50$), it was necessary to sacrifice the incorrect source rates, rendering them too low to be compared with the correct source responses.

The aim of this study was to investigate the neural activity related to the retrieval success and the retrieval attempt in young, middle-age and older adults. Thus, a source memory paradigm (Cansino et al., 2002) that evaluated four possible contexts was used. By using a four-choice task, the probability that a correct source response could arise by chance was reduced ($p = 0.25$). This procedure ensured that enough trials were available to make a powerful contrast between the correctly recognized items in which the source was successfully accorded and trials in which the source was inaccurately retrieved.

The second aim of this study was to examine whether the neurophysiological correlates of the retrieval success and the retrieval attempt change with advancing age by including a group of middle-age adults. Although there was empirical evidence confirming that source memory gradually declined with advancing age (Cansino, 2009; Erngrund et al., 1996), the neural correlates (according to ERP measurements) of the retrieval success and the retrieval attempt in middle-age adults have not been previously reported. The inclusion of this age-group established whether age-related neurophysiological changes were initiated during this stage when behavioral changes also begin to occur. Previously, only one episodic memory study (Guillaume et al., 2009) has included middle-aged adults (50–64 years old) in addition to young (21–30 years old) and old (65–75 years old) adults. Participants in this study performed a recognition task ('old-new' judgments) for famous faces followed by a 'remember-know' task (Tulving, 1985). ERPs that were evoked by correctly recognized faces were compared with those evoked by correct rejections, and a significant difference in ERP amplitude was observed between the middle-aged and young adults. Because the famous faces might have triggered the retrieval of previous knowledge, the ERPs analyzed in this study combined not only episodic but also semantic memory processes.

The retrieval success for the source information and the retrieval attempt, as it was operationalized above, have been evaluated in two previous aging studies. In one study (reported in Trott et al., 1997, 1999), temporal source memory was examined by asking the participants (young adults: 21–28 years old, older adults: 65–81 years old) whether each word was presented in the first or second list during encoding. In the other study (Schiltz et al., 2006), source memory for three different line drawings, which were used as backgrounds to present faces, was evaluated in young (22–27 years old) and older (60–75 years old) adults. The retrieval success was characterized in these studies through the "left parietal" and "right frontal old/new" effects. Trott et al. (1997, 1999) observed the left parietal effect in both young and older adults, but it was only observed in young adults by Schiltz et al. (2006). The left parietal effect in the study by Trott et al. consisted of a positive ERP amplitude that was larger for correct source responses than for incorrect source responses at posterior sites (P3, PZ, and P4); this effect was seen between 490 and 800 ms in young adults and between 500 and 860 ms in older adults. The same characteristics had this effect in the study by Schiltz et al., but it was analyzed between 500 and 700 ms at P3 and P4. The right frontal effect was evident only in young adults (Trott et al., 1997, 1999), although it was not examined by Schiltz et al. (2006). Trott et al. observed a positive ERP amplitude that was larger for incorrect source responses than for correct source responses at both frontal and prefrontal electrode sites between 830 and 1450 ms.

The neural activity that was associated with the retrieval attempt was observed in young adults in a "fronto-central N400 old/new effect" and in a positive component labeled as "late positive component" (Schiltz et al. (2006). Both effects were analyzed at fronto-central electrode sites (FC1, FC2) between 400–500 ms and 500–700 ms, respectively and were characterized by a positive amplitude that was larger for incorrect source responses than for correct rejections; this difference was evident only in the fronto-central N400 effect among the older adults. The retrieval attempt was also associated with a positive amplitude that was larger for incorrect source responses than for correct rejections in the study by Trott et al. (1997, 1999). In young adults, these differences were observed in multiple waveforms between 260 and 480 ms at frontal, central, and posterior sites, in a waveform designated as "posterior old/new effect" between 490 and 800 ms, and in waveforms designated as "posterior" and "anterior old/new" effects between 830 and 1450 ms at prefrontal, frontal and posterior sites; in older adults, the difference was observed in a posterior old/new effect between 500 and 1490 ms.

One potential factor that might explain the discrepancies between these studies is that the participants were requested to provide one ('old-new' judgment) (Schiltz et al., 2006) or two ('old-new' and 'remember-know' judgments) responses (Trott et al., 1997, 1999) before the source judgment. Because the ERPs were recorded before the participants made their decision, it is possible that the actual neural activity related to the retrieval success was not captured in the timeframes analyzed in these experiments (Cycowicz and Friedman, 2003). Recollection accuracy may also influence the quality of the electrophysiological signal recorded during these judgments. If the source memory performance was at chance, then the true recollection processes may be diluted in the recording epochs classified as successful retrieval. The accuracy for recalling source information in the participants was close to the chance level in older adults in these previous studies (Schiltz et al., 2006; Trott et al., 1997, 1999).

Other source memory ERP studies using elderly adults investigated the neural correlates of the retrieval success or recollection by comparing the correct source responses with correct rejections. This comparison failed to exclude the contribution of responses based on the familiarity processes (Friedman and Johnson, 2000). In contrast, comparisons between the correct and incorrect source responses allowed the examination of only successful recollection processes because electrical brain activity related to familiarity was excluded. In these studies, neither Li et al. (2004), who studied young adults from 18 to 34 years old and older adults from 63 to 75 years old, nor Mark and Rugg (1998), who studied young adults from 18 to 30 years old and older adults from 62 to 79 years old found any significant differences between the two age groups in the left parietal old/new effect. In contrast, the right