Neuropsychologia 46 (2008) 679–689

NEUROPSYCHOLOGIA

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Aging memory for pictures: Using high-density event-related potentials to understand the effect of aging on the picture superiority effect

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Received 22 March 2007; received in revised form 19 September 2007; accepted 20 September 2007
Available online 29 September 2007

Abstract

High-density event-related potentials (ERPs) were used to understand the effect of aging on the neural correlates of the picture superiority effect. Pictures and words were systematically varied at study and test while ERPs were recorded at retrieval. Here, the results of the word–word and picture–picture study-test conditions are presented. Behavioral results showed that older adults demonstrated the picture superiority effect to a greater extent than younger adults. The ERP data helped to explain these findings. The early frontal effect, parietal effect, and late frontal effect were all indistinguishable between older and younger adults for pictures. In contrast, for words, the early frontal and parietal effects were significantly diminished for the older adults compared to the younger adults. These two old/new effects have been linked to familiarity and recollection, respectively, and the authors speculate that these processes are impaired for word-based memory in the course of healthy aging. The findings of this study suggest that pictures allow older adults to compensate for their impaired memorial processes, and may allow these memorial components to function more effectively in older adults.

Keywords: Aging; Recognition memory; Picture superiority effect; Event-related potentials; Dual process

1. Introduction

For more than 30 years the picture superiority effect has demonstrated that subjects are more likely to remember items if they are presented as pictures versus words (Shepard, 1976; see Mintzer & Snodgrass, 1999, for review). Recent research has focused on understanding the memorial processes that underlie this picture superiority effect (Ally & Budson, 2007; Langley et al., 2008). Investigations into episodic memory from a dual-process perspective have provided fairly convincing evidence that familiarity and recollection provide independent bases of the recognition of studied items (Woodruff, Hayama, & Rugg, 2006; Yonelinas, 2002). Familiarity has been described as an acontextual sense that a test item has been seen before, whereas recollection has been described as the retrieval of contextual information about a studied item at test (Woodruff et al., 2006). Using high-density event-related potentials (ERPs), Ally and Budson (2007) suggested that pictures enhanced recollection compared to words, serving as the neural basis of the picture superiority effect in young adults. Older adults also demonstrate the picture superiority effect (Park, Puglisi, & Sovacool, 1983; Winograd, Smith, & Simon, 1982). However, many studies have suggested that recollection is impaired in the course of healthy aging (Craik & Jennings, 1992; Light, 1991). The primary goal of the current study was to investigate the effect of aging on the

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doi:10.1016/j.neuropsychologia.2007.09.011

neural correlates of the picture superiority effect. We hoped to determine whether the increased memory for pictures in older adults was due to enhanced recollection of studied items, or whether it was attributable to enhancement of other memorial processes, such as familiarity or post-retrieval verification and monitoring.

Although it is widely acknowledged that aging has an adverse effect on episodic memory (Balota, Dolan, & Duchek, 2000; Craik & Jennings, 1992; Light, 1991; Smith, 1996), exactly how aging affects the processes of recognition memory has been the subject of some debate. Researchers have demonstrated that recollection remains intact in some groups of healthy older adults (Cabeza, Anderson, Locantore, & McIntosh, 2002; Davidson & Glisky, 2002; Duarte, Ranganath, Trujillo, & Knight, 2006). However, the majority of studies report that recollection is generally impaired with age, while familiarity is spared (Daselaar, Fleck, Dobbins, Madden, & Cabeza, 2006; Howard, Bessette-Symons, Zhang, & Hoyer, 2006; Jacoby, 1999; Jennings & Jacoby, 1993; Jennings & Jacoby, 1997; Rybash & Hoyer, 1996; Spencer & Raz, 1995; Titov & Knight, 1997; Yonelinas, 2001; but see Light, Prull, La Voie, & Healy, 1999).

Recent studies have used different methodologies to better understand familiarity in the context of aging (Duarte et al., 2006; Toth & Parks, 2006). The majority of the tasks used in the laboratory to estimate familiarity rely on the ability to effectively report a confidence judgment or one's subjective feeling of familiarity. It has been suggested, however, that perhaps older adults are impaired in their ability to access or report on the phenomenological experience of familiarity (Prull, Dawes, Martin, Rosenberg, & Light, 2006). Yet familiarity is generally thought to be an automatic/obligate process, which likely occurs physiologically with or without one being able to report on the phenomenological experience of familiarity (Ally & Budson, 2007; Ecker, Zimmer, Groh-Bordin, & Meckinger, 2007; Toth, 1996; Yonelinas, 2002; Yonelinas & Jacoby, 1996). In other words, the neural correlate of familiarity is likely to occur in older adults even if they are impaired in their ability to report the subjective feeling of familiarity. The use of a physiologic measure of familiarity might eliminate the need to use subjective reports.

Due to their excellent temporal resolution, ERPs have recently been used to dissociate the processes of familiarity and recollection with a variety of different stimuli and experimental manipulations (Ally & Budson, 2007; Duarte et al., 2006; Li, Morcom, & Rugg, 2004; Woodruff et al., 2006). In addition to helping us understand when specific cognitive processes may occur with precise time sensitivity, ERPs can help to elucidate the duration and interaction of these cognitive processes. The literature reports that ERPs elicited by correctly classified old items (studied) are more positive in nature than ERPs elicited by correctly classified new items (unstudied) (Friedman & Johnson, 2000). This ERP phenomenon is referred to as the "old/new effect." Researchers suggest that a neural correlate of familiarity is an enhanced old/new effect peaking around 400 ms at bilateral frontal electrode sites, that appears to precede controlled attempts by the individual to recollect information (Curran, 2000; Friedman & Johnson, 2000; Rugg et al., 1998). Some researchers have referred to this component as the "N400" or "FN400;" we will refer to this component as the early frontal effect. Previous research has shown that more familiar unstudied test items elicited a larger early frontal effect than unfamiliar unstudied items (Curran, 2000; Goldmann et al., 2003). Further, Duzel, Yonelinas, Mangun, Heinze, and Tulving (1997) asked subjects to make either a "remember" judgment if they remembered specific details of an item's presentation at study, or a "know" judgment if they simply had a feeling of "knowing" that an item was shown at study but could not recollect details of the item's presentation. They found that responses associated with "know" judgments elicited a greater early frontal effect than "remember" judgments. Furthermore, a recent ERP study using confidence ratings suggested that the magnitude of the early frontal effect varied directly with familiarity strength (Woodruff et al., 2006).

Numerous studies have investigated the neural correlate of recollection. The literature describes this correlate as an enhanced old/new effect occurring maximally at left parietal regions between 500 and 800 ms after test stimulus onset. Researchers have often referred to this component as the "LPC;" we will refer to this component as the parietal effect. This effect is greater for items correctly identified as previously studied and is relatively insensitive to alterations in familiarity (Woodruff et al., 2006). Further, Duzel et al. (1997) found that the parietal effect was enhanced by responses associated with "remember" judgments compared to "know" judgments. Some researchers have argued that the parietal effect indexes the amount of information retrieved (Fjell, Walhovd, & Reinvang, 2005; Vilberg, Moosavi, & Rugg, 2006). Although it remains unclear exactly what role the parietal cortex is playing in recognition memory, the parietal activity may reflect the reactivation of the stored memory representation or the actual matching of representations stored in memory with perceptual representations of the test items (Addis & McAndrews, 2006; Ally & Budson, 2007; Schnyer, Nicholls, & Verfaellie, 2005; Wagner, Shannon, Kahn, & Buckner, 2005).

When recollection is poor, difficult, or additional information is needed at retrieval, subjects must engage in post-retrieval processing. It has been suggested that post-retrieval monitoring and verification operates on the product of a retrieval attempt by holding information in working memory while it is evaluated for task relevance (Achim & Lepage, 2005). ERP studies suggest that a late right frontal old/new effect between 1000 and 1800 ms is associated with the ongoing evaluation and monitoring of the product of the retrieval attempt, particularly when the contents of memory are evaluated for specific features or details (Allan, Wilding, & Rugg, 1998; Rugg & Wilding, 2000; Wilding & Rugg, 1996). More recently, investigators have reported evidence of this late frontal effect despite unsuccessful recollection, and suggested that in addition to ongoing evaluation, this activity may reflect an executive search function of the frontal lobes directing subsequent retrieval attempts (Ally & Budson, 2007; Budson et al., 2005; Goldmann et al., 2003; Li et al., 2004).

Research focusing on ERPs and recognition memory in older adults has mainly focused on the parietal and late frontal effects. Most of these studies have reported an attenuation of the parietal