



Effects of aging and divided attention on episodic feeling-of-knowing accuracy



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ABSTRACT

This research investigated the effect of aging on episodic feeling-of-knowing (FOK) using a divided attention (DA) paradigm in order to examine whether DA in younger adults mimics the effects of aging when decreasing either memory encoding or monitoring processes. To that end, four groups of participants were tested on the FOK task: young adults (control group), young adults under DA at encoding, young adults under DA when making FOK judgments, and older adults. Our results showed that DA at encoding in young adults mimicked the effect of aging on memory performance, and also on FOK magnitude and accuracy, supporting the *memory-constraint hypothesis* (Hertzog et al., 2010). However, our results do not completely contradict the *monitoring-deficit hypothesis*, as DA during FOK judgments also affected FOK accuracy, but to a lesser extent than the aging effect or DA during encoding. We suggest that the age-related FOK deficit may be due to a lower level of deep encoding, leading to difficulty retrieving target-related contextual details enabling accurate prediction of subsequent recognition.

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1. Introduction

Older adults have greater difficulty with memory tasks that require the implementation of effortful strategic processes for good performance. One argument is that this memory dysfunction is linked to difficulties with metamemory (e.g., Craik & Byrd, 1982). Metamemory refers to people's knowledge, monitoring and control of their memory processes (Nelson & Narens, 1990). Failure to monitor memory would mean that older adults would be unable to compensate for their memory difficulties, or find it difficult to allocate cognitive resources efficiently to ensure adequate memory function. Feeling-of-knowing (FOK) is the subjective experience whereby one fails to recall information, yet is confident that the information is still available in memory and could be retrieved in the future. This metamemory judgment, based on monitoring of the memory retrieval process, plays a central role in regulating memory functioning. FOK judgments are experimentally assessed by a procedure in which participants are asked to estimate the likelihood that they will subsequently recognize a piece of information that they had failed to recall earlier, from either semantic (Hart, 1965) or episodic memory (Schacter, 1983).

To explain how FOK judgments are formed, Koriat and Levy-Sadot (2001) proposed a model which combined two FOK hypotheses: the cue-familiarity account (Metcalf, Schwartz, & Joaquim, 1993; Reder & Ritter, 1992) and the accessibility account (Koriat, 1993). According to this model, a rapid preliminary FOK is based on assessment of cue familiarity (Metcalf et al., 1993; Reder & Ritter, 1992). If the cue evokes a sufficient degree of familiarity, a deliberate search for the solicited target in memory is engaged; FOK judgment is then based on assessment of the accessibility of partial information related to the target (Koriat, 1993). The vividness or quantity of this partial information determines predictions of future retrieval. Several studies have shown that the partial information influencing FOK judgments may be either structural-phonological (Blake, 1973; Koriat, 1993) or semantically related (Koriat, 1993; Schacter & Worling, 1985). More recently, other studies have suggested that recollection, defined as the explicit retrieval of contextual information regarding the encoding episode (e.g., Yonelinas, 2002), may be central to guiding episodic FOK judgments (Brewer, Marsh, Clark-Foos, & Meeks, 2010; Hicks & Marsh, 2002; Sacher, Taconnat, Souchay, & Isingrini, 2009; Souchay, Moulin, Clarys, Taconnat, & Isingrini, 2007; Thomas, Bulevich, & Dubois, 2011). For instance, studies have found that FOK judgments and accuracy are correlated with recollection assessed through a recognition Remember/Know paradigm (Hicks & Marsh, 2002; Souchay et al., 2007). More direct support was recently provided by Thomas et al. (2011) who demonstrated that the retrieval of correct contextual information (the valence of the target) influenced FOK judgments and accuracy. Thus, episodic FOK judgments

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and accuracy may depend on the accessibility of partial information, such as contextual details.

In the aging literature, no age-related differences have been found regarding FOK accuracy for information stored in semantic memory (e.g., Allen-Burge & Storandt, 2000). However, a number of studies have demonstrated a deficit in episodic FOK accuracy in older adults (Perrotin, Isingrini, Souchay, Clarys, & Tacconnat, 2006; Souchay & Isingrini, 2012; Souchay, Isingrini, & Espagnet, 2000; Souchay et al., 2007; Thomas et al., 2011, but see MacLaverly & Hertzog, 2009). Two hypotheses have recently been proposed to explain this deficit: the *inferential-deficit hypothesis* and the *memory-constraint hypothesis* (see Hertzog, Dunlosky, & Sinclair, 2010). According to the *inferential-deficit hypothesis*, the deficit may be due to difficulty evaluating accurately accessible information that may be relevant for subsequent target recognition. This hypothesis has recently been supported by Thomas et al. (2011) who demonstrated that older adults may not use accessible partial information effectively when making FOK judgments, leading to reduced FOK accuracy. Inferential processes might occur at later stages of FOK judgments, i.e. accessibility assessment of partial information stage (Koriat & Levy-Sadot, 2001). Those would demand important executive resources, because of the high frontal-executive contribution to the memory strategic retrieval processes (Moscovitch & Winocur, 1992; see Perrotin, Tournelle, & Isingrini, 2008 for a detailed discussion about this point). Numerous studies have highlighted the role of prefrontal cortex in the production of accurate episodic FOK judgments: (1) frontal damage is associated with impaired FOK accuracy (Janowsky, Shimamura, & Squire, 1989; Pinon, Allain, Kefi, Dubas, & Le Gall, 2005); (2) prefrontal regions are involved during accurate FOK judgments in neuroimaging studies (Maril, Simons, Mitchell, Schwartz, & Schacter, 2003; Schnyer, Nicholls, & Verfaellie, 2005); and (3) older adults' FOK accuracy positively correlates with neuropsychological measures of frontal function (Perrotin et al., 2006; Perrotin et al., 2008; Souchay et al., 2000). Thus, the low frontal-executive functioning in older adults would lead to reduced ability to evaluate accessible information, which is needed to make accurate FOK judgments. By contrast, the *memory-constraint hypothesis* proposed by Hertzog et al. (2010) suggests that the episodic FOK deficit in older adults may derive from an age-related impairment in memory capacities (for a similar argument, see Perfect & Stollery, 1993). This hypothesis is based on the idea that memory strength influences FOK accuracy. In line with this hypothesis, experimental studies manipulating encoding in young adults have demonstrated that FOK accuracy increases when the quality of encoding increases (Carroll & Nelson, 1993; Hertzog et al., 2010; Lupker, Harbluk, & Patrick, 1991; Nelson, Leonesio, Shimamura, Landwehr, & Narens, 1982; Sacher et al., 2009). For instance, Lupker et al. (1991) showed that a deep encoding condition not only increased explicit cued-recall performance, but also FOK judgments and FOK accuracy as compared to a shallow encoding condition. Sacher et al. (2009) recently showed that divided attention at encoding, a factor that reduces recollection but leaves familiarity unaffected (see Yonelinas, 2002), affects both memory performance and FOK judgments and accuracy. Such outcomes indicate that FOK judgments and accuracy are influenced by the quality of memory encoding. With regard to aging, the *memory-constraint hypothesis* is supported by Souchay et al.'s (2007) finding showing that the age-related deficit in episodic FOK accuracy was mainly explained by a lack of recollection, as measured by a recognition Remember/Know paradigm. According to Hertzog et al. (2010), the lack of accessible contextual information in older adults might be due to impoverished representation of the items, as a result of limited initial encoding. More precisely, they suggested that deficient encoding processes reduce the amount of accessible contextual information, leading to poor FOK accuracy. Thus, the *memory-constraint hypothesis* predicts that when age groups are matched for memory performance, FOK accuracy would be similar in the two groups (see Hertzog et al., 2010).

Numerous studies have suggested a parallel between the effects of aging and the effects of divided attention (DA) to help explain age-related differences in memory processes. The suggestion is that effortful cognitive operations, such as elaboration at encoding and strategic processes at retrieval, require substantial attentional resources associated with efficient frontal lobe functioning (Moscovitch & Umiltà, 1990, 1991) and that older adults have fewer of these resources. According to Craik (Craik, 1983; Craik & Byrd, 1982), if DA in young adults mimics the effect of aging, a reduction in processing resources could be a mediating factor of age-related episodic memory deficits. One way to test this hypothesis is to reduce processing resources in young adults by asking them to perform a concurrent task during encoding or retrieval and to compare their memory performance with that of older adults. Following this line, several studies have shown that the memory performance of young adults under DA is similar to that of older adults (e.g., Craik & Byrd, 1982; Jennings & Jacoby, 1993; Kelley & Sahakyan, 2003; Luo & Craik, 2009; Pansky, Goldsmith, Koriat, & Pearlman-Avni, 2009). For instance, Jennings and Jacoby (1993) showed that younger adults under DA at encoding exhibited a pattern of memory performance that was very similar to that of older adults. Their results indicated that both aging and DA had a detrimental effect on recollection processing but left familiarity processing intact, suggesting that older adults have difficulty recollecting details presented at study. More recently, Luo and Craik (2009) showed that DA at retrieval in young adults mimicked aging with regard to recollection, suggesting that retrieving specific contextual information is resource-demanding and that the age-related difficulty in such processing reflects a reduction in available processing resources.

The purpose of this study was therefore to investigate the effects of aging on episodic FOK accuracy, using a DA paradigm to test whether DA in younger adults mimics the effects of aging by decreasing either memory encoding or monitoring processes. To assess these hypotheses, we examined the effects of aging and DA on memory and metamemory performance at two distinct phases of an episodic FOK task. The FOK task comprised a cue-target word-pair learning phase, a cued-recall phase, a FOK-judgment phase, and a recognition phase. The first phase involved memory encoding processes, whereas the FOK-judgment phase involved memory monitoring processes. In this experiment, four groups of participants were tested: young adults under full attention (control group), young adults under DA at encoding, young adults under DA during the FOK-judgment phase, and older adults. First, we predicted that young adults under DA at encoding would exhibit a pattern of memory and FOK performance that would be very similar to that of the older adults. We expected that DA at encoding would reduce memory and FOK performance (FOK judgments and accuracy) in young adults, as previously shown by Sacher et al. (2009) and would equate age groups on memory performance, leading to equivalent FOK performance in the two groups. This prediction is consistent with the *memory-constraint hypothesis* (Hertzog et al., 2010). Next, we predicted that young adults under DA during FOK judgments would also exhibit a pattern of FOK performance that would be very similar to that of the older adults, even if memory performance is unaffected. We expected that DA during FOK judgments would reduce FOK judgments and FOK accuracy in young adults. We predicted that the secondary task carried out by younger adults during the FOK-judgment phase would more specifically disrupt monitoring processes based on the retrieval and evaluation of accessible partial information used to make accurate FOK judgments, resulting in similar FOK performance in the two age groups.

2. Method

2.1. Participants

A total of 120 adults took part in our study, 60 older adults (17 men, 43 women; age range 61–82, $M = 69.45$ years, $SD = 5.69$)

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