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Article *in* Memory · February 2015

DOI: 10.1080/09658211.2015.1011168 · Source: PubMed

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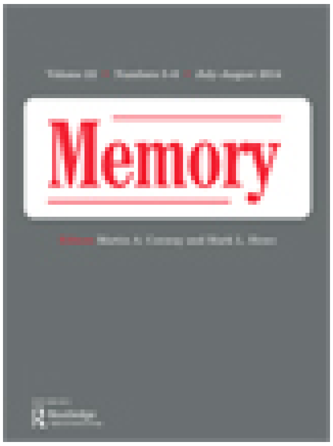

Memory
Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/pmem20

Susceptibility to retroactive interference: The effect of context as a function of age and cognition

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Published online: 16 Feb 2015.

Memory, 2015
http://dx.doi.org/10.1080/09658211.2015.1011168

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Susceptibility to retroactive interference: The effect of context as a function of age and cognition

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(*Received 28 June 2014; accepted 19 January 2015*)

Previous studies have shown that contextual cues improve memory performance and reduce interference in younger adults. However, it is not clear whether middle-aged and older adults can also benefit from contextual cues, or if this ability diminishes with ageing and cognitive decline. In order to test this question, we tested 69 middle-aged adults (aged 30–50 years) and 65 older adults (aged 65–85). Participants completed a retroactive interference paradigm with or without contextual cues. Cognitive functioning of older adults was assessed using the Montreal Cognitive Assessment, which is a sensitive and highly validated tool to detect cognitive decline in older age. The results showed that while middle-aged adults were able to benefit from context to improve recognition and reduce interference, older adults were not able to benefit from it. However, when we compared older adults with lower (<26) and higher (≥26) scores on the Montreal Cognitive Assessment, we found that older adults with high cognitive functioning could benefit from context advantage at retrieval to improve recognition compared to those with lower cognitive functioning. Yet, similar to older adults with lower cognitive functioning, they could not benefit from context advantage at encoding and hence were still susceptible to interference.

Keywords: Context effect; Retroactive interference; Ageing; Older adults; Middle-aged adults.

Every perceptual experience is made up of several elements including central and background features. While the central features receive most of our attention, others remain at the periphery of our attention, serving as the context of our focally attended experience (Mayes, Macdonald, Donlan, Pears, & Meudell, 1992; Murnane & Phelps, 1994; Smith, 2007). Context serves as an essential component in learning and memory processes (Godden & Baddeley, 1975; Rutherford, 2000; Smith, 1979, 1986; for a review see Smith & Vela, 2001; Tulving & Thomson, 1973). Studies have found that contextual information affects not only what we will remember under any circumstances but also how susceptible we may be to possible interference (e.g., Balsam & Tomie, 2014; Barak, Vakil, & Levy, 2013; Levy-Gigi, Kelemen, Gluck, & Keri, 2011; Levy-Gigi & Vakil, 2010, 2012; for a review see Smith & Bulkin, 2014; Smith, Handy, Angello, & Manzona, 2013). In the present study we investigate the effects of context on memory and susceptibility to interference across age. This study has two goals. First, we aim to test age-related differences in the ability to benefit from contextual cues in conditions of retroactive interference. Second, we concentrate on older adults to examine possible effects of general cognitive functioning on this ability.

In two recent studies we used a retroactive interference paradigm and showed that context

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has a dual role in memory processes—at encoding and at retrieval (Levy-Gigi & Vakil, 2010, 2012). In a classic retroactive interference paradigm, participants see two subsequent lists of items—a list of target items and a list of interfering items—followed by a recognition test. In our studies we manipulated the contextual similarities between the three different phases of the task. This manipulation enabled us to test the effects of target–interference and target–test similarities as well as the interaction between them on correct recognition and rates of interference. When we tested adolescents and younger adults (Levy-Gigi & Vakil, 2010, 2012), we compared their performance on four possible contextual conditions (ABA, ABB, AAB and AAA, letters representing the context in the target, interference and test phases) and found that the best memory performance was achieved when the target and interfering items were presented in different contexts (context advantage at encoding) and the target and test items were presented in the same context (context advantage at retrieval; i.e., the ABA condition). In this condition participants were able to recognise most of the target items and were less susceptible to misleading information. However, when the target, interference and test items were presented in the same context, participants had no contextual information that helped them distinguish the target and interfering items or better recognise the target compared to the interfering items (i.e., the AAA condition). In this condition, recognition of target items was significantly lower, while susceptibility to interference was significantly higher. Note that in the ABA condition the same pattern of results was observed when the target and test items were presented as pictures while the interfering items were presented as words or when the target and test items were presented as words while the interfering items were presented as pictures. Similarly, in the AAA condition we received the same pattern of results when all the items were presented as pictures and when all the items were presented as words (Levy-Gigi & Vakil, 2010, 2012, 2014). To summarise, our previous results clearly demonstrate a dual accumulative effect of context in conditions of retroactive interference in younger adults. However, it is not yet clear whether context has similar effects on memory performance in middle-aged and older adults.

Studies, which tested context effects in older age, revealed that older adults show impaired ability to bind target and contextual information into complex memories, especially when it requires self-initiated processing, for example, to remember the face to which a given name belonged (Chalfonte & Johnson, 1996; Chee et al., 2006; Naveh-Benjamin, 2000 for meta-analysis see Old & Naveh-Benjamin, 2008). However, older adults were able to use contextual cues at least as well as younger adults when using simple stimuli such as background colours and presentation formats (i.e., pictures vs. words), which require minimal (if any) self-initiated processing (Craik & Schloerscheidt, 2011). In the present study, we manipulated context by using different presentation formats of the same stimuli (pictures vs. words). In this case, people are focused on identifying the object, while the presentation format is in the periphery of their attention, serving as the context of the focally attended experience. Many previous studies have manipulated context in a similar way (e.g., Kellogg, 2001; Levy-Gigi & Vakil, 2010, 2012; Pezdek & Greene, 1993). Most importantly, it was found to be beneficial in other studies of older adults (Gallo, McDermott, Percer, & Roediger, 2001; Vakil, Melamed, & Even, 1996). Therefore, we assumed that older adults in our study would be able to efficiently use it to improve their memory performance.

Previous studies that tested retroactive interference and ageing have shown that vulnerability to retroactive interference increases with age, due to the impaired ability of older adults to suppress irrelevant information. Specifically, older adults tend to process the irrelevant information and confuse it with more relevant information (Solesio-Jofre et al., 2011; Williams, Sullivan, Morra, Williams, & Donovick, 2014). Based on our previous findings (Levy-Gigi & Vakil, 2010, 2012, 2014) in the present study, we used a retroactive interference paradigm with (ABA) or without (AAA) contextual cues. We expected that in the ABA condition, presenting the target and interfering items in a different context, would help older adults to better differentiate relevant and irrelevant information and reduce interference compared to the AAA condition in which the two-item lists are presented in the same context. In addition, we anticipated that in the ABA condition the contextual similarity between the target (but not the interfering) and the test items would improve recognition in a three-alternative forced choice test, compared to the AAA condition in which all the items are presented in the same context, and hence the retrieval cues are not specific.

Our second aim was to test whether the ability to benefit from context at an older age is affected by general cognitive functioning. Specifically, it is possible that the ability to encode and bind target and contextual information relates to the level of general cognitive functioning and, therefore, deteriorates with age. If this is the case, older adults with higher compared to lower cognitive functioning would show a better ability to benefit from context at encoding and at retrieval. We used the highly validated Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005) to evaluate cognitive functioning (Montero-Odasso et al., 2009; Nazem et al., 2009). We divided our participants into two groups according to their cognitive functioning, based on a clinical cut-off point (= 26), which was validated as an indicator for mild cognitive impairment in prior studies (Kasten, Bruggemann, Schmidt, & Klein, 2010; McLennan, Mathias, Brennan, & Stewart, 2010; Oren et al., 2015).

We hypothesised that the overall performance in the ABA condition would be significantly better compared to the performance in the AAA condition. In addition, we expect that middle-aged adults will have better overall memory performance than older adults. Finally, we anticipate a similar performance pattern in both age groups. However, in the older adults group, we expect that the performance will differ as a function of cognitive functioning. Hence, only high cognitive functioning older adults (MoCA scores ≥ 26) will be able to benefit from context at encoding and at retrieval, while lower cognitive functioning older adults will have lower performance either with or without contextual cues.

METHODS

Participants and design

We tested 134 participants, 69 middle-aged adults (M_{age} = 39.64 years, range 30–50 years) and 65 older adults (M_{age} = 76.5 years, range 65–85 years). All participants volunteered to participate in the study without compensation. Exclusion criteria included any history of traumatic brain injury or neurological episodes (see a detailed description of the sample see Table 1). Participants were randomly assigned to one of the two contextual conditions (ABA or AAA) reflecting context advantage or disadvantage.

Materials and procedure

The context retroactive interference paradigm. A detailed description of this paradigm and the study procedure can be found in previous publications (Levy-Gigi & Vakil, 2010, 2012). In this paradigm, participants view two lists of unrelated items in succession—a list of target items and a list of interfering items—followed by a recognition test. The contextual similarity between these three phases is manipulated. In the ABA condition, the target and the test items are presented in the same context while the interfering items presented in a different context. In the AAA condition all items are presented in the same context. Based on our previous findings, suggesting similar pattern of results when the target items are presented as pictures or words (Levy-Gigi & Vakil, 2010, 2012, 2014) in the present study, the target items were always presented as pictures. The test was a three-alternative forced-choice test in which participants had to choose between the target item (hits), the interfering item (old false alarm) and a new item that was never presented before (new false alarm). After completing the test, participants were debriefed.

The Montreal Cognitive Assessment (MoCA). This is a highly validated measure for cognitive functioning (Nasreddine et al., 2005). It assesses several

TABLE 1
Demographic characteristics of the sample

			Older adults divided by cognitive functioning	
	Middle-aged adults (N = 69)	*Older adults (N = 65)*	*Low (N = 42)*	*High (N = 23)*
Age (years)	39.64 (4.8)	76.5 (5.0)	80.38 (6.2)	79.17 (8.5)
Male/female	23/46	16/49	11/31	5/18
Education (years)	13.2 (1.58)	11.94 (3.94)	11 (3.9)*	13.65 (3.6)*
Estimated IQ	11.67 (2.84)	11.91 (2.55)	10.95 (2.4)*	13.65 (1.9)*
MoCA	N/A	22.46 (4.32)	20.21 (3.7)*	26.57 (1.0)*

*Significant differences between means at the $p < .05$ based on Scheffé's post hoc paired comparisons.

cognitive domains including: short-term memory is assessed by two learning trials of five nouns and delayed recall after approximately five minutes. Visuospatial abilities are assessed using a clock-drawing task and a three-dimensional cube copy. Multiple aspects of executive functions are assessed using an alternation task adapted from the trail-making B task, a phonemic fluency task and a two-item verbal abstraction task. Attention, concentration and working memory are evaluated using a sustained attention task (target detection using tapping), a serial subtraction task, and digits forward and backward. Language is assessed using a three-item confrontation naming task with low-familiarity animals, repetition of two syntactically complex sentences and the aforementioned fluency task. Finally, orientation to time and place is evaluated. Scores ranged from 0 to 30.

RESULTS

Hit rates

The percentage of hits was analysed in a 2 Context Condition (ABA vs. AAA) × 2 Age Group (middle-aged vs. older adults) ANOVA. The results are depicted in Figure 1. We found a significant main effect of Context Condition ($F(1, 130) = 25.4$, $p < .001$), indicating that, as predicted, the overall percentage of hits was significantly higher in the ABA compared to the AAA condition. In addition, we found a significant main effect of Age Group ($F(1, 130) = 547.01$, $p < .001$), indicated that, as predicted, middle-aged adults had significantly higher hit rates compared to older adults. Finally, and most importantly, we found a significant interaction between Context Condition and Age Group ($F(1, 130) = 18.95$, $p < .001$). Follow-up t-test analyses revealed that while middle-aged adults performed significantly better in the ABA condition compared to the AAA condition ($t(67) = 5.78$, $p < .001$), older adults performed similarly in the two contextual conditions ($t(63) = .61$, $p > .05$). The results indicate that middle-aged adults can benefit from contextual advantages at encoding and at retrieval and use it to improve their correct recognition. However, older adults cannot benefit from context in a similar manner, and their percentage of hits in both context conditions is equally low.

False alarm rates

The percentage of false alarms was analysed in a mixed-design ANOVA, with Context Condition (ABA vs. AAA) and Age Group (middle-aged vs. older adults) as between participants variables and Error Type (old false alarm vs. new false alarms) as a within participant variable. False alarms represent conditions in which participants mistakenly attributed items to the target list. Old false alarms refer to conditions in which participants chose an item from the interfering list, while new false alarms refer to conditions in which they chose a new item that was never presented before. By comparing the response

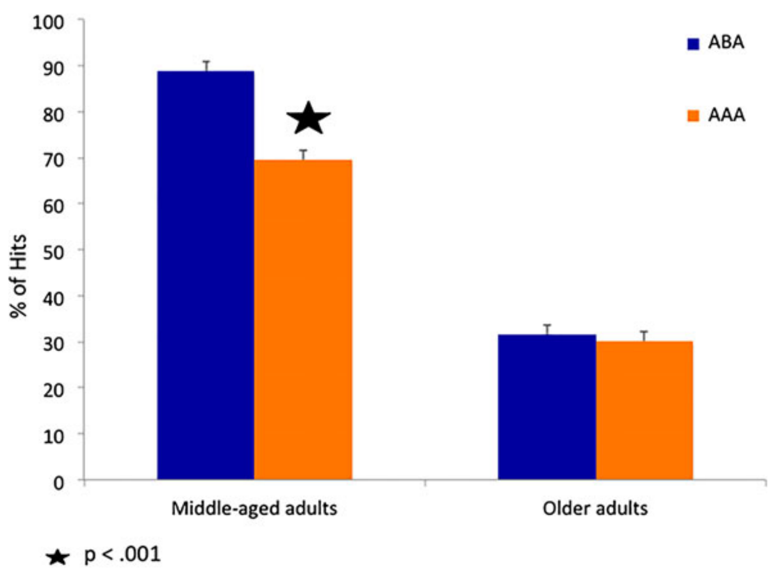

Figure 1. Mean percentage of hits as a function of context condition (ABA vs. AAA) and age (middle-aged adults vs. older adults).

rates in these two measures we can decide whether the participants' errors were due to a general memory problem (old ≤ new false alarms) or if it can be attributed to interference (old > new false alarms; see Levy-Gigi & Vakil, 2010, 2012 for similar approach). The results are depicted in Figure 2. Main effects are redundant and illustrate a mirror picture of the hit rates effects, and therefore are not reported. There was a significant Context Condition × Age Group × Error Type interaction ($F(1, 130) = 10.18$, $p < .005$). In order to reveal the source of the interaction, we conducted a mixed-design ANOVA, with Context Condition (ABA vs. AAA) as a between participants variable and Error Type (old false alarm vs. new foil false alarms) as a within participant variable for each one of the age groups. We found that in older adults there was no significant interaction between Context Condition and Error Type ($F(1, 63) = 3.8$, $p > .05$) indicating similar high susceptibility to misleading information in both the ABA and AAA conditions. However, in middle-aged adults there was a significant interaction between Context Condition and Error Type ($F(1, 67) = 7.08$, $p < .05$). Follow-up paired sample t-test analyses with Bonferroni correction (=.0125) revealed that, as predicted, in the ABA condition the percentage of old false alarms did not differ from the percentage of new false alarms ($t(35) = 1.75$, $p > .05$). However, in the AAA condition the percentage of old false alarms was significantly higher compared to new false alarms ($t(32) = 3.8$, $p < .005$). The results indicate that while middle-aged adults were able to use contextual cues, when available, to eliminate the effect of interference, older adults were susceptible to interference whether such cues were available or not. It is important to note that the percentage of new false alarms did not differ as a function of contextual condition ($F(1, 130) = .05$, $p > .05$), hence, although older adults had higher rates of new false alarms compared to middle-aged adults, in both age groups these rates did not differ as a function of contextual condition.

The effect of cognitive functioning on the ability to benefit from contextual cues

We divided the older adults in our sample into two groups according to a well-established clinical cut-off point: higher cognitive functioning (MoCA scores ≥ 26) and lower cognitive functioning (MoCA scores < 26). See Table 1 for a description of the participants in each of these sub-groups. In order to test whether there are differences between older adults with higher and lower cognitive functioning in the ability to use contextual cues to improve recognition, we conducted a 2 Context Condition (ABA vs. AAA) × 2 Cognitive Level (higher vs. lower) ANOVA on the percentage of hits. To control for possible effects of age within the older adults group, we included it as a covariate. We found a significant main effect of Context Condition ($F(1, 60) = 4.47$,

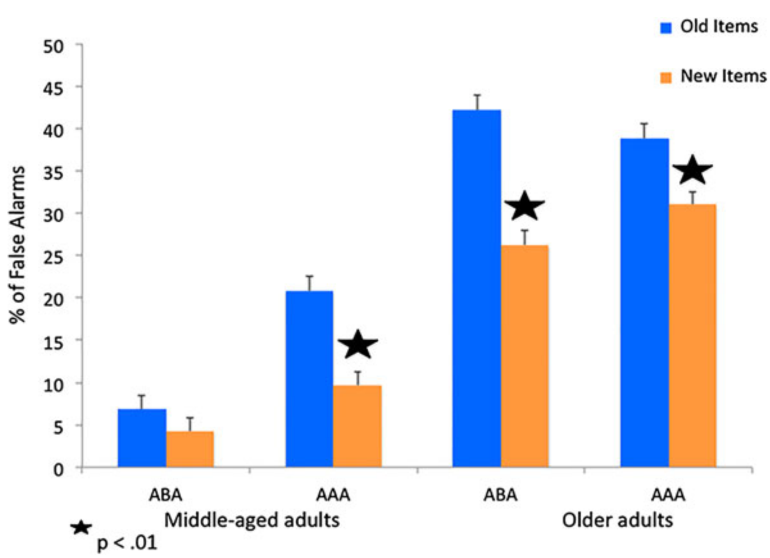

Figure 2. Mean percentage of false alarms (old vs. new) as a function of context condition (ABA vs. AAA) and age (middle-aged adults vs. older adults).

$p < .05$), and a strong trend towards significance of Cognitive Level ($F(1, 60) = 3.94$, $p = .052$). Most importantly, we revealed a significant Context Condition by Cognitive Level interaction ($F(1, 60) = 6.96$, $p < .05$). Follow-up *t*-test analyses showed that while higher cognitive functioning older adults performed significantly better in the ABA condition compared to the AAA condition ($t(20) = 2.32$, $p < .05$), older adults with lower cognitive functioning performed similarly in the two contextual conditions ($t(40) = .61$, $p > .05$). In order to test differences in susceptibility to interference between older adults with lower and higher cognitive functioning, we conducted a mixed-design ANOVA, with Context Condition (ABA vs. AAA) and Cognitive Level (lower vs. higher) as between participants variables and Error Type (old false alarm vs. new foil false alarms) as a within participant variable, while using age as a covariate. The results revealed no significant differences between the lower and higher cognitive functioning groups in rates of false alarms ($F(1, 61) = .79$, $p > .05$). To summarise, the results indicate that older adults with higher cognitive functioning can benefit from contextual cues in order to improve recognition rates, compared to those with lower cognitive functioning. However, they do not differ from older adults with lower cognitive function in rates of old false alarms and hence cannot use contextual cues in order to avoid interference. More importantly, there was no significant correlation between Age and MoCA scores ($r(65) = -.11$, $p = .37$). In addition, Age served as a covariate in all of our analyses. Hence the ability of higher cognitive functioning older adults to benefit from contextual cues is above and beyond possible differences in age within the older adults group.

DISCUSSION

While younger adults can use contextual cues to improve their memory, it is not clear whether middle-aged and older adults can also benefit from it, or if this ability diminishes with ageing and cognitive decline. In order to test this we compared memory performance of middle-aged and older adults in conditions of retroactive interference with or without contextual cues. Our first aim was to test age related differences for individuals' ability to benefit from contextual cues to improve recognition and reduce interference. Our second aim was to investigate the possible moderating role of cognitive functioning in older adults' capability to benefit from contextual cues.

As predicted, we found that the overall performance was significantly better with contextual cues compared to performance without contextual cues. Hence, in line with our previous findings, in the ABA condition the overall correct recognition was higher, while the overall interference was lower relative to the AAA condition (Levy-Gigi & Vakil, 2010, 2012). In addition, the overall memory performance of middle-aged adults was significantly better compared to older adults. These results reflect a common view in the literature that age attenuates memory performance (Edmonds, Glisky, Bartlett, & Rapcsak, 2012; Memon, Bartlett, Rose, & Gray, 2003; Naveh-Benjamin, 2000; Park, Smith, Morrell, Puglisi, & Dudley, 1990; Roberts, Ly, Murray, & Yassa, 2014).

Most importantly, we found that performance varied as a function of age and contextual condition. Specifically, in accordance with our predictions, middle-aged adults showed better memory performance when contextual cues were provided. Hence, they were able to use these cues both to improve recognition of target items and to buffer the effect of interference. These results replicate our previous findings in younger participants (Levy-Gigi & Vakil, 2010, 2012). However, as opposed to our prediction, the performance of older adults did not differ as a function of contextual conditions. Hence, they performed similarly in the presence or in the absence of contextual cues. It suggests that even when using context manipulation, which requires minimal (if any) self-initiated processing, older individuals, as a group, cannot benefit from it to improve their memory performance. Specifically, they display not only lower correct recognition but also greater susceptibility to possible retroactive interference compared to middle-aged adults.

A potential explanation for these results may relate to the neural mechanisms of information processing. It has been claimed that older adults' brains encode similar events 'in the same old way' (Craik & Salthouse, 2008; Craik & Simon, 1980). This claim suggests that older adults cannot use all the aspects of information to their advantage nor can they exclude pieces of information as disadvantages to facilitate better encoding. Similarly, it is possible that older adults cannot encode and process context in a way that helps them improve their memory performance. Specifically, despite the fact that target and interfering items were presented in different contexts, older adults could not distinguish them. This impairment in encoding information may then lead to impoverished retrieval.

Alternatively, it is possible that the impaired performance is due to the tendency of older adults to depend on a familiarity-based response strategy (Aizpurua, Garcia-Bajos, & Migueles, 2011; Duarte, Graham, & Henson, 2010; Murphy, West, Armilio, Craik, & Stuss, 2007). Therefore, older adults have difficulty to differentiate between novel stimuli and ones that have been previously encountered. Support for such an assertion can be found in animal (e.g., Bachevalier et al., 1991; Burke, Wallace, Nematollahi, Uprety, & Barnes, 2010; de Lima et al., 2005; Herndon, Moss, Rosene, & Killiany, 1997; Insel et al., 2008; Pietá Dias et al., 2007) and human studies (Cansino, Hernández-Ramos, & Trejo-Morales, 2012; Craik & McDowd, 1987; Kausler, Wiley, & Lieberwitz, 1992; Lamar, Resnick, & Zonderman, 2003; Pihlajamäki et al., 2004; Zelinski & Burnight, 1997) as well as in neuroimaging studies that show alterations in the dentate gyrus region which is responsible for detecting novel experiences (Azab, Stark, & Stark, 2013; Bakker, Kirwan, Miller, & Stark, 2008; Lacy, Yassa, Stark, Muftuler, & Stark, 2011; Yassa & Stark, 2011). Accordingly, since both target and interfering items may be familiar to the same extent, older adults may tend to confuse them, despite the fact that they were presented in different contexts.

As can be seen in Figure 2, the percentage of false alarms in both contextual conditions was relatively high in the older adults group. A possible explanation for this is the impaired ability to distinguish between target and interfering items together with the familiarity of the interfering items and their proximity to the memory test. This pattern may further indicate that in older age such mechanisms have a stronger effect than the effect of context.

As predicted, we found significant associations between memory performance and cognitive functioning, indicating that older adults with higher cognitive functioning were able to benefit from contextual cues and improve their correct recognition rates compared to older adults with lower cognitive functioning. These results add to the growing evidence that shows associations between the levels of cognitive functioning and the ability to benefit from context in memory tasks (Anguera et al., 2013; Benichov, Cox, Tun, & Wingfield, 2012; Braver et al., 2001; Braver, Satpute, Rush, Racine, & Barch, 2005; Gutchess et al., 2007; Hogan et al., 2012; Milham et al., 2002; Persson et al., 2004; Wingfield, 1996). However, it is important to note that while past studies include mostly various domains in working memory, executive functioning and long-term recognition memory, our study is one of the first to our knowledge to report associations between cognitive functioning and contextual effects in a retroactive interference paradigm.

Interestingly, while high functioning older adults could use contextual information to improve correct recognition, it did not help them reduce the effect of interference. A possible explanation for these results can be found in the inhibition-deficit theory, which suggests that the ability to suppress irrelevant information declines with age (Cohn, Dustman, & Bradford, 1984; Hasher, Lustig, & Zacks, 2007; Hasher & Zacks, 1988; Ludwig, Borella, Tettamanti, & De Ribaupierre, 2010). Hence, even older adults with higher cognitive functioning can get distracted or confused by information that is not necessarily relevant for remembering the target items. Support for this explanation can be found in imaging studies in high cognitive functioning older adults, which show decline in brain regions responsible for memory performance, before it becomes manifested behaviorally (Hogan et al., 2012).

The current study has several limitations. First, the older adults group included individuals from a relatively high range of ages (65–85 years of age). Although we controlled for possible effects of age, it is still possible that other age-related differences affected the overall performance of the participants in this group. In addition, we used the MoCA individual face-to-face assessment (Nasreddine et al., 2005). While this is a highly reliable tool (Lerch, Decker-Maruska, Fleck, & Hannusch, 2010), only few studies have used it as a foundation to differentiate levels of cognitive functioning. Moreover, although it provides a comprehensive cognitive assessment, including short-term memory, visuospatial abilities, attention, concentration, working memory and executive functions, it is very short and aims to provide a quick general evaluation. Future studies may aim to use this tool as well as other cognitive tests to explore the connection between the ability to benefit from contextual information and general cognitive functions as well as other more specific functions such as working memory and attention. Finally, we do not have neuroimaging evidence to support possible neural mechanisms that may account for the observed results.

In conclusion, the present study utilised a retroactive interference paradigm to shed light on the puzzling effects of ageing and cognitive functioning for individuals' ability to benefit from contextual cues. The results suggest deteriorating effects of ageing that are visible even in the most optimum contextual conditions. Moreover, while high cognitive functioning leads to a moderate improvement in recognition, even high functioning older adults are susceptible to interference, similar to older adults with lower cognitive functioning.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

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