

Is there a deficit in recognition in old age?

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Abstract

Background: There is some debate over the effect of aging on the ability to recognize previously processed information. The aim of the present study is to analyze, by means of different measurements, whether aging has differential effects on recall and recognition of visual and verbal materials. **Method:** A within-subject design was used to compare two groups of different age (younger, older) in tasks of recall and recognition of images and of the verbal descriptors exchanged in a conversation. **Results:** The results indicated that, unlike the recall and recognition of words, better in younger participants, the recall and recognition of images was equal in both groups, or even better in older participants when assessed by means of d' . Nevertheless, a more strict recently proposed measurement, the conditional probability for recall given recognition, yielded significant age differences in all instances. Besides, the conditional probability shows the aging changes usually found in the serial position curve: decline of the primacy effect, while maintenance of the recency effect. **Conclusions:** Results are explained according to the theories that postulate two components in the process of recognition (familiarity and recollection), which are independently affected by aging.

Keywords: age differences, recognition, conditional probability, recall.

Resumen

¿El reconocimiento empeora al envejecer? **Antecedentes:** existe controversia acerca del efecto del envejecimiento sobre la habilidad para reconocer información previamente procesada. El principal objetivo del estudio es analizar, mediante distintas medidas, si al envejecer se produce un declive diferencial del recuerdo y el reconocimiento de materiales visuales y verbales. **Método:** se comparó con un diseño intra-sujetos el rendimiento de dos grupos de distinta edad (joven, mayor) en tareas de recuerdo y reconocimiento de imágenes y de los descriptores verbales intercambiados en una conversación. **Resultados:** los resultados indicaron que, a diferencia del recuerdo y reconocimiento de palabras, mejor en jóvenes, el recuerdo y reconocimiento de imágenes es igual en ambos grupos, o incluso mejor en los mayores mediante estimaciones como d' . Sin embargo, una medida más estricta recientemente propuesta, la probabilidad condicionada de recordar la información reconocida, muestra diferencias significativas en función de la edad en todos los casos. Además, dibuja el cambio habitual de la curva de posición serial al envejecer: declive del efecto de primacía y mantenimiento del efecto de recencia. **Conclusiones:** los resultados se explican en el marco de las teorías que postulan dos componentes en el proceso de reconocimiento (familiaridad y recuperación), sobre los que el envejecimiento tiene distintos efectos.

Palabras clave: envejecimiento, reconocimiento, probabilidad condicionada, recuerdo.

There is some debate as to whether recall and recognition memory processes decline differentially in old age. Most studies report age-related decline in recall (for a review, see, Luo & Craik, 2008). Nevertheless, some authors have published findings that suggest that older participants sometimes recall images (e.g., Luo, Hendriks, & Craik, 2007), and self-referent descriptors as well as do younger participants (e.g., Mueller, Wonderlich, & Dugan, 1986). Age-related decline in recall does not typically affect all serial curve positions and thus, it is often the case that the primacy effect disappears while the recency effect remains unchanged (e.g., Simón, Ruiz-Gallego-Largo, & Suengas, 2009).

Regarding recognition, there is no agreement as to whether it declines in old age or remains intact. Opposite results have been published suggesting either the occurrence or absence of age-related differences in recognition of pictures, faces, and words (e.g., Bartlett & Memon, 2007; Porras & Salinas, 2011; Ruiz-Gallego-Largo, Simón, & Suengas, 2012; Sekuler, McLaughlin, Kahana, Wingfield, & Yotsumoto, 2006; Suengas, Ruiz-Gallego-Largo, & Simón, 2010). Uttil, Henry, and Baltimore (2007) maintain that studies that have not found age-related differences in recognition have overlooked the possibility of a ceiling effect in young participants' results. According to dual-processing models (for a review, see Yonelinas, 2002), recognition takes place on the basis of two processes – familiarity and recollection – differentially affected by aging. Familiarity is an automatic process requiring minimal cognitive effort, whereas recollection is a process equivalent to recall and is more cognitively demanding (e.g., Yonelinas, 2002). While the recollection component of recognition declines with age, the familiarity component does not (e.g., Uttil et al., 2007). Danckert and Craik (2013) argue that when

studies have not detected age-related differences, it is because participants were able to achieve satisfactory recognition through familiarity, with recollection hardly intervening at all. They argue this has led researchers to overestimate performance in older participants and situate younger participants' ability at ceiling level. Thus, they suggest using a new measure – conditional probability for recall given recognition – to more accurately estimate recognition in older participants. Using that measure, Danckert and Craik (2013) analyzed performance on three tasks with words as stimuli. They concluded that, indeed, when the probability of recognition indicated no age-related differences, the conditional probability for recall given recognition detected age-related differences.

As more age-related differences are generally found using word stimuli than picture stimuli, it would be interesting to confirm the validity of the conditional probability for recall given recognition as an estimate of recognition, not only using words as Danckert and Craik did (2013), but pictures as well. This comparison is worth pursuing because many studies have suggested that older participants can recognize pictures not merely as well as young people, but even better (e.g., Simón et al., 2009). Superior performance in older participants would rule out a ceiling effect in young people as a possible explanation for the results.

To ascertain how useful conditional probability for recall given recognition is at estimating recognition, we proposed a within-subjects design comparing recall and recognition performance in two age groups (young, older), using pictures and verbal descriptors exchanged in a conversation as stimuli. The conditional probability may be an interesting alternative means of measuring the recollection component of recognition (the remember/know paradigm; e.g., Clarys, Isingrini, & Gana, 2002). The conditional probability does not require participants to discriminate between simply “knowing” or actually “remembering” what specific stimulus appeared before, and instead, it is measured directly, based on typical recall and recognition (YES/NO) measures. According to Danckert and Craik (2013), its ease of calculation makes the conditional probability a very useful tool with great potential for research on recognition processes in older participants.

In this study, in keeping with the literature on performance when different stimulus modalities are used, our first hypothesis was that age-related differences in memory ability would be smaller with picture stimuli than word stimuli (e.g., Spencer & Raz, 1995). According to the bibliography (e.g., Craik & McDowd, 1987), our second hypothesis was that there would be age-related differences in stimulus recall – visual and verbal – but no age-related differences in stimulus recognition ability. In light of earlier recognition results (Simón, Suengas, Ruiz-Gallego-Largo, & Bandrés, 2013), we expected to find no age-related differences in discrimination ability (d') for visual information; but we did expect to find age-related differences in discrimination ability (d') for verbal information. Finally, regarding the conditional probability of recall given recognition, according to Danckert and Craik's (2013) findings, we hypothesized that where recognition (d') showed no age-related differences, this measure would detect them; but not when recognition (d') was better in older participants than younger participants.

Method

Participants

Seventy-six volunteers participated in this study. Half were young adults (32 women and 6 men) ranging in age from 21 to 31 years old ($M = 23.45$, $SD = 2.26$), and having between 18 and 24 years of formal education ($M = 19.03$, $SD = 1.34$). The other half were older participants (33 women and 5 men) ranging in age from 65 to 84 years old ($M = 70.47$, $SD = 4.35$), and having 8 to 35 years of formal education ($M = 17$, $SD = 5.64$). The sample was collected through incidental sampling. It was made up of students at the Madrid Complutense University: younger participants in the Psychology and Speech Therapy Departments; and older participants from the Adult Continuing Education Program. Before the study began, all participants signed informed consent forms. We considered older participants' participation in academic activities, having passed the university's admissions test, and scoring over 26 ($M = 27.49$, $SD = 1.41$) on the Spanish adaptation by Lobo, Saz, Marcos, and Grupo ZARADEMP (2002) of the Mini-Mental State Examination, as indicators of adequate cognitive ability.

Instruments

Stimuli for the *Pictures* task included 100 color photographs of elements representing different categories (clothing, animals, modes of transportation, furniture). From earlier studies, we knew they were all clearly recognizable and easy to label (e.g., Simon et al., 2009). The pictures were compiled in an A4-sized notebook. Fifty images were presented in the initial acquisition phase, and a total of 100 pictures in the recognition phase.

Materials for the *Conversation* task consisted of 80 “I am (descriptor)” and “you are (descriptor)” statements. Those statements were presented one per page in an A4-sized notebook. We established previously that the descriptors were equally applicable to men and women, young and older adults, and that the ones exchanged during the conversation phase versus recognition phase did not differ in average frequency of use (e.g., Ruiz-Gallego-Largo et al., 2011).

On both tasks, stimuli (pictures and verbal descriptors) were counterbalanced so each participant was presented with a different set of stimuli in a different order. This was true in the acquisition and recognition phases.

Procedure

The two tasks were performed individually and in a single session. Task order was counterbalanced to neutralize any possible effects of practice and fatigue. Participants were not specifically instructed to remember the information, nor were they warned that tests of recall and recognition would follow.

Pictures task. During the acquisition phase, a booklet of 50 pictures was presented. The instructions prompted participants to simply observe the pictures attentively as they looked through the pages. A free recall test followed, which asked participants to recall all the pictures they could from the set they had just seen. Next, a recognition (YES/NO) test was administered, presenting participants with another notebook containing 100 pictures (the 50 presented initially plus 50 distractors). Here participants had to indicate whether or not they had seen the picture before.

Conversation task. The instructions indicated this would be a simulated conversation in which interlocutors alternately make statements about each other. Participants had to pay attention to what the examiner said as well as what they themselves said. Two practice trials were conducted to ensure that participants understood the mechanics of the conversation. The examiner and the participant were each given a booklet with 20 sentences. Of those, they had to read half about themselves (e.g., “yo soy amable [I am kind]”) and the other half about their interlocutor (e.g., “tú eres capaz [you are capable]”), as specified at the top of each page. Following that 40-statement exchange, a free recall test was applied, prompting participants to recall all the descriptors exchanged in the conversation, independently of whether the examiner or the participant said them. A recognition (YES/NO) test followed, using an 80-word booklet (one per page; the 40 descriptors mentioned in the conversation plus 40 distractors). Participants had to indicate whether each descriptor was mentioned by one of the interlocutors during the conversation.

Data analysis

The following dependent variables were assessed in both tasks: total recall, measured by the proportion of stimuli correctly remembered; recognition, estimated as d' ($z_{p(H)} - z_{p(FA)}$, where $z_{p(H)}$ and $z_{p(FA)}$ are the standard scores corresponding to the proportion of hits and false alarms, respectively); and conditional probability for recall given recognition, that is, the proportion of stimuli recalled from among those recognized.

For each dependent variable, a 2x2 mixed analysis of variance (ANOVA)¹ was conducted, with age of participants (young, older) as the between-subjects factor and stimulus type (picture, word descriptor) as the within-subjects factor. Post hoc comparisons were carried out using the Bonferroni test. The level of significance was set at .05. All data analyses were conducted with the SPSS program, version 19.0.

Results

Table 1 displays means and standard deviations for the proportion of stimuli correctly recalled, d' , and the conditional probability for recall given recognition, with the two types of stimuli (pictures, words), for the two age groups (young, older).

Recall

Results indicated significant main effects of age, $F(1, 74) = 12.36, p = .001, \eta_p^2 = 0.14, \beta = 0.93$, stimulus type, $F(1, 74) = 363.51, p < .001, \eta_p^2 = 0.83, \beta = 1.00$, and the Age x Stimulus type interaction, $F(1, 74) = 6.12, p = .016, \eta_p^2 = 0.08, \beta = 0.69$. Thus, young participants recalled more information than older participants, pictures were better recalled than words, and post hoc comparisons indicated there were no significant differences between young and older participants on picture recall, $t(74) = 1.22, p = .227, d = 0.14$. There were, however, on word recall, which was significantly better in younger than older participants, $t(74) = 6.43, p < .001, d = 0.74$ (see Table 1).

Recognition

Results showed no significant main age effect, $F(1, 74) = 0.02, p = .889, \eta_p^2 = 0.01$ or $\beta = 0.05$, but yielded significant main effects of stimulus type, $F(1, 74) = 585.90, p < .001, \eta_p^2 = 0.89, \beta = 1.00$, and of the Age x Stimulus type interaction, $F(1, 74) = 25.78, p < .001, \eta_p^2 = 0.26, \beta = 1.00$. Participants generally recognized pictures better than words, and post hoc comparisons showed that older participants recognized pictures significantly better than young participants, $t(74) = 3.14, p = .002, d = 0.36$. However, young participants recognized words significantly better than older participants, $t(74) = 3.19, p = .002, d = 0.37$ (see Table 1).

Conditional probability

Results yielded significant main effects of age, $F(1, 74) = 21.79, p < .001, \eta_p^2 = 0.23, \beta = 1.00$, and stimulus type, $F(1, 74) = 134.37, p < .001, \eta_p^2 = 0.65, \beta = 1.00$. The Age x Stimulus type interaction was not significant, $F(1, 74) = 3.42, p = .068, \eta_p^2 = 0.04, \beta = 0.48$. Therefore, young participants were better able to recall information they recognized than older participants, and pictures that were recognized were better recalled than words.

In keeping with dual-processing theories of recognition, the conditional probability of recall given recognition estimates recognition's recollection component, which is postulated to be equivalent to recall. Thus, we were interested in determining whether this new measure would follow the serial position curve usually observed in old age, wherein the recency effect (i.e., better

Table 1
Means (standard deviations) for: Recall (proportion of stimuli recalled), recognition (d'), and conditional probability for recall given recognition (total, initial, middle, and final serial positions), for pictures and words, for young and older participants.

Stimulus type	Age group	Dependent variable					
		Recall	Recognition (d')	Conditional probability			
				Total	Initial	Middle	Final
Pictures	Young	0.44 (0.11)	3.84 (0.60)	0.45 (0.11)	0.55 (0.25)	0.42 (0.20)	0.57 (0.24)
	Older	0.41 (0.10)	4.22 (0.46)	0.40 (0.10)	0.45 (0.20)	0.35 (0.19)	0.59 (0.21)
Words	Young	0.25 (0.07)	2.35 (0.59)	0.33 (0.08)	0.39 (0.30)	0.23 (0.18)	0.51 (0.31)
	Older	0.17 (0.05)	1.94 (0.53)	0.23 (0.06)	0.15 (0.24)	0.20 (0.19)	0.44 (0.32)

recall of items at the end of the series than those in the middle) remains intact, but the primacy effect (i.e., better recall of items at the beginning of the series than those in the middle) disappears. We calculated conditional probabilities for recall given recognition for the first five items (initial position), the 10 middle items (middle position), and the last five items (final position) of the series of pictures and words. The results are displayed in Table 1 and Figure 1. A mixed $2 \times 2 \times 3$ ANOVA was carried out on conditional probability for recall given recognition with age (young, older) as between-subjects factor, and stimulus type (picture, word) and serial position (initial, middle, final) as within-subjects factors. Results yielded significant main effects of age, $F(1, 74) = 10.79, p = .002, \eta_p^2 = 0.13, \beta = 0.90$, stimulus type, $F(1, 74) = 67.65, p < .001, \eta_p^2 = 0.48, \beta = 1.00$, and serial position, $F(2, 148) = 30.22, p < .001, \eta_p^2 = 0.29, \beta = 1.00$. Therefore, the conditional probability of recall given recognition was, on the whole, better in young participants than older ones. Also, it was higher for pictures than words. As for serial position, post hoc comparisons showed that stimuli recognized from the beginning of the series, $t(75) = 2.90, p = .005, d = 0.37$, and the end of the series, $t(75) = 7.70, p < .001, d = 0.91$, were remembered better than those in the middle. Nevertheless, those effects were moderated by significant interactions of Serial position \times Age, $F(2, 148) = 3.72, p = .026, \eta_p^2 = 0.05, \beta = 0.68$, and Serial position \times Stimulus type, $F(2, 148) = 3.77, p = .049, \eta_p^2 = 0.04, \beta = 0.59$. In the first case, according to post hoc comparisons and shown in Figure 1, young participants exhibited both primacy, $t(37) = 3.91, p < .001, d = 0.66$, and recency effects, $t(37) = 5.48, p < .001, d = 0.86$; whereas older participants exhibited only the recency effect, $t(37) = 6.30, p < .001, d = 0.97$, but no primacy effect, $t(37) = 0.00, p = 1.000, d = 0.09$. As for the Serial position \times Stimulus type interaction, post hoc comparisons showed that, with pictures as stimuli, both primacy, $t(75) = 3.26, p = .002, d = 0.40$, and recency effects, $t(75) = 5.90, p < .001, d = 0.65$, were present;

whereas, with words as stimuli, there was a recency effect, $t(75) = 6.99, p < .001, d = 0.74$, but no primacy effect present, $t(75) = 0.65, p = .522, d = 0.16$.

In summary, when verbal stimuli were utilized, young participants exhibited better recall, recognition, and recall given recognition than older participants. However, while older participants recalled pictures just as well as young participants, and recognized them even better, their probability for recall given recognition was lower than young participants'.

Discussion

Our first hypothesis was that older participants would recall fewer pictures and words than young adults. According to our results, however, older participants recalled pictures just as well as young participants, although, consistent with our hypothesis, they recalled the descriptors exchanged in conversation worse than their younger counterparts. It is unusual for older participants to recall as much information as young ones, but some studies have similarly reported no age-related differences, especially when pictures were used as stimuli (e.g., Luo et al., 2007). Our second hypothesis postulated that there would be no age-related differences in the ability to discriminate images previously presented from novel ones, yet there would be in the case of verbal descriptors. The results only partially support that assertion in that older participants recognized which pictures they had seen better, in fact, than young participants. This finding is unusual and suggests it is unlikely that the task was so easy that young adults reached a ceiling effect on it, as older participants outperformed them. Thus, it is possible to rule out a ceiling effect in young adults' performance as a possible explanation for the lack of age-related differences in recognition, as estimated by d' (e.g., Utzl et al., 2007). Like other authors (e.g., López-Higes, Rubio,

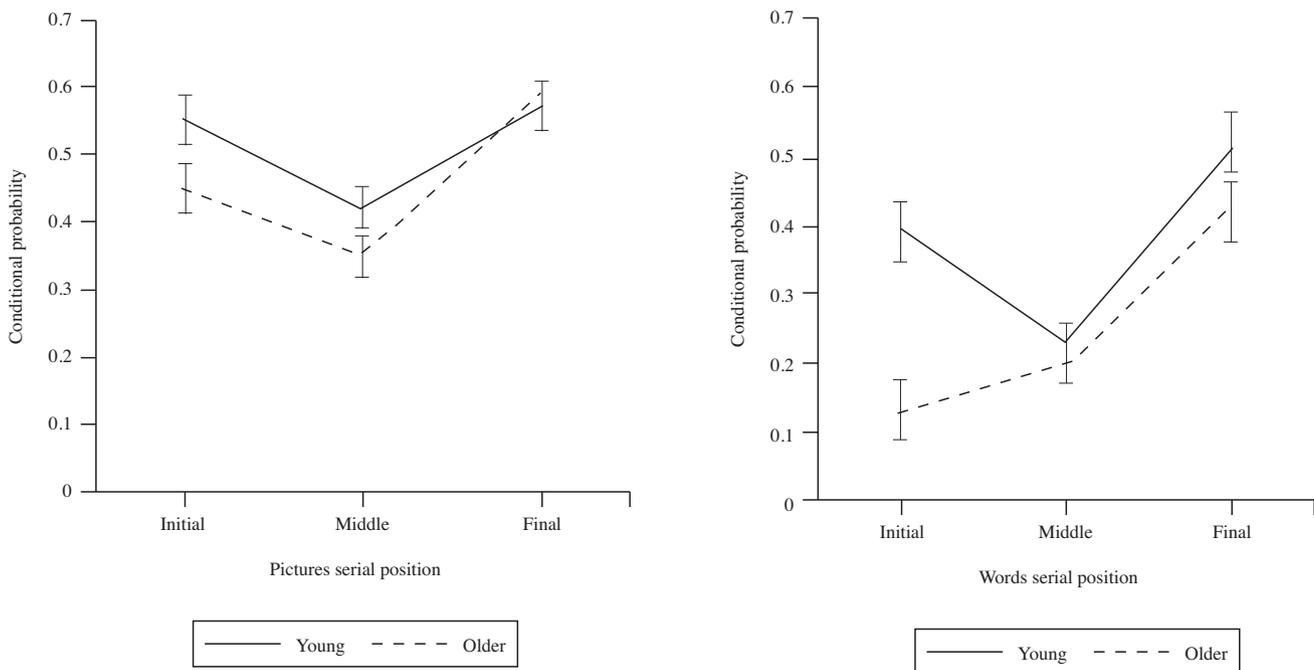


Figure 1. Conditional probability of recall given recognition in pictures and words for each serial position (initial, middle, final) and age group (young —, older ---)

& Martín-Aragoneses, 2010; Spencer & Raz, 1995), we contend that the ability to discriminate information previously processed remains stable over the course of normal aging.

Our results do not completely agree with research findings of no significant differences in recognition as a function of age (e.g., Sekuler et al., 2006), or with findings of age-related decline in recognition (e.g., Soei & Daum, 2008). Based on our results, it would be an exaggeration presenting recognition ability as “improving” in old age, especially considering that word recognition was worse in the older group than in the young group. Nonetheless, we can defend that recognition remains intact when the type of material (e.g., visual) facilitates initial processing enough to ensure later discrimination ability. According to Luo and Craik (2008), that is presumably because, both at encoding and recognition, pictures compensate for the age-related deficits found in more cognitively demanding tasks.

Our results indicate age-related decline in recall and recognition of verbal descriptors exchanged in conversation, which was predictable given earlier research findings (e.g., Luo et al., 2007). It was not entirely surprising, therefore, that the conditional probability of recall given recognition of verbal descriptors would be better in young vs. older participants. It was surprising and it is our most remarkable result however that, despite having had equal recall and better recognition of images than younger participants, older participants did recall images they had recognized worse than their younger counterparts. In that context, the measure that Danckert and Craik (2013) proposed seems to be more sensitive to decline in memory performance than other measures more often employed.

This result can be explained within the framework of dual-processing theories of recognition asserting that age does not have an impact on the familiarity component that enables recognition in certain tasks (e.g., Yonelinas, 2002). This would account for the estimates of d' for pictures in our older participants being even higher than in young participants. Conversely, the recollection component of recognition, equivalent to conscious recall, is postulated to decline with age (e.g., Howard, Bessette-Symons, Zhang, & Hoyer, 2006). Danckert and Craik (2013) presented the conditional probability of recall given recognition as an estimate of this conscious recollection component of recognition and as in their study here, too, it has proven to be a useful indicator of age-related decline. We must point out that, being an indicator of the posited recollection component of recognition, the conditional probability for recall given recognition follows the same pattern of serial position effects usually found in older participants. Thus, Figure 1 illustrates how the primacy effect disappears and the recency effect remains intact in older participants' serial position curve. That finding is consistent with those from past research (e.g., Simón et al., 2009). The lack of primacy effect is usually explained by the age-related deficit in self-initiated processes required to retain the beginning of a series of stimuli, which in turn depends on working memory performance (e.g., Spinnler, Della Sala, Bandera, & Baddeley, 1988). Additional processing is not needed to recall the end of a series, which is presumably more automatically recalled (e.g., Craik & McDowd, 1987). These results are also consistent with those of authors who applied

different methodologies and thus for example, Oberauer (2005) demonstrated that working memory structural models should include familiarity and recollection processes to most accurately fit the reported recognition performance results as a function of age.

To calculate the conditional probability for recall given recognition, participants do not need to make additional judgments while carrying out the recognition task (e.g., Clarys et al., 2002). This ease of calculation makes the conditional probability an interesting alternative measure, and a useful suggestion on the part of Danckert and Craik (2013) for research on differential age-related decline in recall and recognition memory. Differences between our results – measures of recall, recognition, and conditional probability – can be explained in Craik and McDowd's (1987) terms. These authors posit that recall is an activity that, far from being automatic, places high cognitive demands on working memory, because it requires more self-initiated processing resources than does recognition. The aging process has an especially large impact on self-initiated processing, whereas recognition is considered a more automatic process, as it is based in part on a sense of familiarity. That would explain why it is less affected by age. Therefore, in answer to the question of whether there is an age-related recognition deficit, it depends not only on stimulus type, but above all, on what measure is used to assess recognition performance.

A possible limitation of this study, perhaps attributable to the sample's demographic characteristics (especially in the older group), was the disparity in years of formal education across participants. Nevertheless, there is no agreement in the literature about the impact of education on memory performance. On the one hand, authors such as Keightley, Winocur, Burianova, Hongwanishkul, and Grady (2006) have reported that, when years of education is entered as a covariate in analyses of recognition, the results do not differ from those of regular analyses of variance. In other words, education does not account for differences in recognition ability. On the other hand, studies like the one by Tractenberg, Aisen, and Chuang (2005) have found that years of formal education explains some of the variance in measures of recall in adult populations.

As possible future lines of research, it would be interesting to apply the conditional probability of recall given recognition to measure recognition in other contexts where age-related decline has usually not been observed, for example, when the stimuli are faces and scenes of positive emotional valence (e.g., Suengas et al., 2010).

Acknowledgements

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Footnote

¹ An alternative analysis might have been ANCOVA, with the years of education as covariable, but its application is unwarranted in this case, since there is no independence between the covariable and the independent variables.

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