
DO HEALTHY ELDERLY, LIKE YOUNG ADULTS, REMEMBER ANIMATES BETTER THAN INANIMATES? AN ADAPTIVE VIEW

Aurélia Bugaiska

Université de Bourgogne Franche-Comté and LEAD-CNRS, Dijon, France

Alain Méot

Université Blaise Pascal and LAPSCO-CNRS, Clermont-Ferrand, France

Patrick Bonin

Université de Bourgogne Franche-Comté and LEAD-CNRS, Dijon, France

Background/Study Context: It has been found that young adults remember animates better than inanimates. According to the adaptive view of human memory, this is due to the fact that animates are more important for fitness purposes than inanimates. This effect has been ascribed to episodic memory, where older people exhibit difficulties.

Methods: Here the authors investigated whether the animacy effect in memory also occurs for healthy older adults. Older and young adults categorized words for their animacy characteristics and were then given an unexpected recognition test on the words using the Remember/Know paradigm. Executive functions were also evaluated using several measures.

Results: For both overall Recognition and Remember responses, a reliable animacy effect on hit rates was found in young but not in older adults. Controlling for certain executive functions led to reliable and comparable animacy effects in both groups. There was no reliable effect of animacy on Know responses.

Conclusion: Thus, unlike young adults, older adults do not remember animates better than inanimates; this pattern can be attributable to a decline in executive functions.

Adaptive memory is the view championed by Nairne and colleagues (Nairne, 2010, 2013; Nairne & Pandey, 2008a) that the functional characteristics of human memory have been sculpted by evolutionary pressures faced by our ancestors in the distant past. The core assumption of the adaptive memory view is that information related to fitness is crucial and should thus be remembered better than non-fitness-related information. This view is

Received 19 August 2014; accepted 12 August 2015.

Address correspondence to Aurélia Bugaiska, LEAD-CNRS (UMR 5022), University of Bourgogne, Pôle AAFE-Esplanade Erasme, BP 26513, 21065 Dijon, Cedex, France. E-mail: aurelia.bugaiska@u-bourgogne.fr

supported by various lines of evidence. First, the survival processing advantage (Nairne & Pandeirada, 2008b; Nairne, Thompson, & Pandeirada, 2007) is based on the finding that when items (words or pictures) are processed for their survival value in a fictitious survival scenario (e.g., is a *coat* useful in a situation where you are stranded in the grasslands of a foreign country with no basic supplies), they are remembered better than when they are processed according to other deep encoding control conditions (e.g., words are rated for pleasantness). The second type of evidence is the animacy effect. This relates to the observation that animate entities (e.g., *snake, cow, woman*) are remembered better than inanimate entities (e.g., *mountain, bottle, car*); because animates can be predators, prey, or potential sexual mates, they are of greater importance in terms of fitness value than inanimates, and are therefore given priority for processing and are remembered better. Animacy effects in memory have been found with words (Bonin, Gelin, & Bugaiska, 2014; Nairne, VanArsdall, Pandeirada, Cogdill, & LeBreton, 2013), animate versus inanimate properties linked to nonwords (VanArsdall, Nairne, Pandeirada, & Blunt, 2013), and pictures (Bonin et al., 2014). These effects have been observed in recall rates and in recognition accuracy. Of particular interest here is that, using the Remember/Know paradigm (Gardiner, 1988), in which participants are asked to indicate whether they remember (R) contextual details of recognized items (e.g., a feeling, a location) or whether they just know (K) that the items have been presented, participants give more R responses for animate than inanimate items, but K responses are the same for the two categories (Bonin et al., 2014). This pattern of findings suggests that animacy effects in memory are episodic in nature, because episodic memory is characterized by the remembering of contextual information. The proximate mechanisms underpinning animacy effects have just started to be explored. We will return to this issue in Discussion. To date, animacy effects have been investigated in young adults but not in healthy elders, although, as discussed below, we believe that this is a highly relevant issue. The aim of our study was thus to address this issue.

It is now well established that cognitive performance tends to decline with age (Craik & Salthouse, 2008). More particularly, aging leads to a deterioration of episodic memory. In the memory aging literature, the findings obtained from different paradigms indicate that aging disrupts recollection to a greater extent than familiarity (Yonelinas, 2002). Of particular interest here, certain studies using the Remember/Know paradigm (Gardiner, 1988; Tulving, 1985) have shown an age-related decline in remembering (i.e., in R responses), but, in most cases, no corresponding effect in knowing (i.e., in K responses, see Bugaiska et al., 2007; Bunce, 2003; Clarys, Bugaiska, Tapia, & Baudouin, 2009; Perfect & Dasgupta, 1997). To account for the differences in the rate of R responses between younger and older people, some researchers have put forward the idea that this is attributable to a decline in executive functioning. Executive control is a multicomponent construct comprising a range of different processes involved in the planning, organization, coordination, implementation, and evaluation of many of our nonroutine activities (Glisky, 2007). The executive decline hypothesis put forward to account for the age-related decline in cognitive performance (West, 1996), and more particularly in memory performance, has received considerable empirical support (see Moscovitch & Winocur, 1992; Parkin, 1997). Traditionally, executive functions are thought to be associated with the functioning of the frontal lobes. These brain areas are the earliest and the most extensively affected by aging (Raz, 2000; West, 1996). Executive functions are thought to enable appropriate strategies to be used during encoding and recognition in order to improve the memory trace. One hypothesis is that the deterioration of executive functioning reduces elderly people's ability to initiate the encoding of target information appropriately for a durable explicit representation. Using the Remember/Know paradigm, a number of studies have investigated this hypothesis and

have provided interesting findings suggesting that the effect of age in recollection experience is determined by the integrity of executive functions (Bugajska et al., 2007; Clarys et al., 2009).

In the literature on adaptive memory, there are only a few studies that have investigated the survival processing advantage in aging. As explained above, the survival effect refers to the observation that encoding lists of unrelated words within the framework of a survival scenario leads to better memory performance than other well-known (deep) encoding strategies (Nairne et al., 2007). Studies on the survival effect in memory in relation to aging have produced conflicting results: three studies found that the survival effect was well preserved in aging (Nouchi, 2012; Pandeirada, Pinho, & Faria, 2014; Yang, Lau, & Truong, 2014), whereas two other studies did not show any survival processing benefit in the memory performance of older adults (Otgaar, Jelicic, & Smeets, 2015; Stillman, Coane, Profaci, Howard, & Howard, 2014). Consequently, the issue of whether or not the survival processing advantage is maintained across the life span requires further research. In the present study, we focused on the animacy effect in memory, and not on the survival processing advantage, because animacy effects seem to be robust in young people and they also relate directly to the issue of adaptive memory.

In a previous study, we established that the animacy effect in memory was found on R responses (an index of recollection) but not K responses (Bonin et al., 2014). Moreover, several studies have found that older adults are less likely to report recollective experience accompanying their recognition responses (Bugajska et al., 2007; Bunce, 2003; Clarys et al., 2009; Perfect & Dasgupta, 1997). Based on these two observations, we hypothesized that the animacy effect would be reduced in older adults. If this is the case, the next question concerns how this decline comes about. As reviewed above, several findings in the literature suggest that age-related declines in episodic memory are attributable to a selective decline in executive functions (Bugajska et al., 2007; Clarys et al., 2009). Therefore, in the present study, we evaluated the memory performance of young and older adults, and we also measured three specific executive functions (updating, shifting, and inhibition of a proponent response) described in Miyake et al.'s (2000) theoretical model and below.

METHODS

Participants and Background Measures

Fifty participants took part in this experiment, divided into two independent groups: 25 young subjects (10 men and 15 women) aged 18–37 years ($M = 22.52$, $SD = 4.33$), and 25 elderly subjects (4 men and 21 women) aged 60–81 years ($M = 67.6$, $SD = 5.42$). All participants were volunteers and had at least 8 years of formal education. The elderly subjects all lived at home and were recruited from leisure clubs and the senior citizens' university. None were taking medication likely to affect their intellectual abilities. They scored above the cutoff of 27 points on the Mini-Mental State Examination (MMSE; Folstein, Fostein, & McHugh, 1975). The groups differed in years of education, $t(48) = 2.5$, $p = .016$ (young: $M = 13.76$, $SD = 2.13$; old: $M = 11.52$, $SD = 3.95$), with more years of education for the younger than the older group. Nevertheless, in each group, years of education did not correlate with any outcome measure of memory performance. Therefore, this variable was not included as a covariate in the analyses. Finally, there was a difference between the two groups in verbal abilities on the Mill-Hill test (Deltour, 1993), i.e., a multiple choice

synonym vocabulary test, $t(48) = 3.85$, $p < .001$, in favor of the older adults ($M = 26.2$, $SD = 4.45$) compared with the younger adults ($M = 20.72$, $SD = 5.56$).

Material and Design

Participants performed a recognition memory test using the Remember/Know/Guess (R/K/G) method, and tests of executive function (Plus-Minus test, N-Back test, and Stroop Color-Word Test). All participants were tested individually and were informed that the experiment involved memory measures.

Stimuli for Encoding

For the R/K/G paradigm, the material was the same as that used by Bonin et al. (2014) and consisted of 56 nouns selected from Snodgrass and Vanderwart's (1980) and Bonin, Peereman, Malardier, Méot, and Chalard's (2003) databases. Each word referred to either an animate or an inanimate object. The words were divided into two sets of 28 items (animates versus inanimates) matched for the *surface variables* of number of letters and bigram frequency, the *lexical variables* of book frequency, subtitle frequency, age of acquisition, number of orthographic neighbors, and orthographic uniqueness point, and the *semantic variables* of conceptual familiarity, imageability, image variability, concreteness, and emotional valence. The statistical characteristics of the controlled variables can be seen in Table 1 in Bonin et al. (2014, p. 374). In addition, 56 new words (half animate and half inanimate) were added for the "new" responses in the recognition task. These new words ("new") matched the initial experimental words ("old") on objective word frequency.

Executive Functioning Tests

Executive functioning was assessed using tasks predominantly tapping the specific executive functions of shifting, updating, and inhibition. The tasks were selected on the basis of proposals formulated by Miyake et al. (2000).

2-Back test. The 2-back letter task (Gevins & Cutillo, 1993) is hypothesized to tap the updating executive component. In this test, the participant listens to a continuous sequence of letters and must decide and say whether each letter matches the one presented two back in the sequence. The list is composed of 30 items and the score is the number of correct responses.

Table 1. Correlations between the executive functions scores and with the first factor from the PCA computed using the three measures

Measure	Stroop Color-Word	Plus-Minus	Factor
2-Back	.18 / -.17 / .06	.26 [†] / -.16 / .38 [†]	.72*** / .35 [†] / .78***
Stroop Color-Word		.18 / .11 / .09	.62*** / .58** / .43*
Plus-Minus			.72*** / .67*** / .78***

Note. The first value was computed using all participants, whereas the second and third were limited to the young and older groups.

*** $p < .001$; ** $p < .01$; * $p < .05$; [†] $p < .1$.

Stroop Color-Word Test (SCWT). The SCWT (Stroop, 1935) was used to measure the inhibition executive component. There are three subtests, each displaying 100 stimuli. In the first subtest (word reading), participants are asked to read words describing a color printed in black. In the second subtest (color naming), they are instructed to name the color of crosses (e.g., XXX). In the third subtest (color-word interference), they have to name the color of the color-word that is printed in incongruously colored ink (e.g., the word *red* is written in green). In each subtest, participants are instructed to name the colors as quickly as possible for 45 s, and the number of correct responses is recorded. An interference score is computed as follows: color-word interference score = [(word reading score × color naming score)/(word reading score + color naming score)].

Plus-Minus test. The plus-minus task (Spector & Biederman, 1976; adapted from Jersild, 1927) is a paper-and-pencil task composed of three lists of 30 two-digit numbers. Participants have to add 3 to each number on the first list, subtract 3 from each number of the second list, and alternate between adding 3 and subtracting 3 from the numbers on the third list. The time (in seconds) taken to complete each of the three lists is measured. The dependent measure is shifting cost, calculated by subtracting the mean total time for addition-only and subtraction-only lists from total time for the alternating list.

Procedure

Participants were tested individually, seated comfortably in a quiet room. First, they carried out an animate-inanimate categorization task. They were given a brief definition of what is meant by *animate* versus *inanimate* (e.g., an animate item can move autonomously, whereas an inanimate item cannot). They were told to decide as quickly as possible whether each word referred to an animate or an inanimate item, indicating their choice by pressing a different key. Each trial began with a fixation point (+) displayed in the middle of the screen for 500 ms. A word was then displayed in the middle of the screen and remained there until the participant responded. The words were presented in random order. Response times were recorded. After this categorization task, the participants were given 5 min to perform two interference tasks commonly used to evaluate executive functions: first the Stroop task and then the plus-minus task. After that, the participants were given the recognition task in which all 112 words (56 targets and 56 fillers) were randomly presented. For each word, participants were told to say if they recognized it from the list seen earlier. In addition, for each word they recognized, they had to indicate if their response was a remember (R), know (K), or guess (G). They were instructed to give an R response when the word evoked a specific recollection of the learning sequence, for example, it brought to mind a particular association, image, or some other personal experience, or because something about its appearance or position could be recalled. They were instructed to give a K response if they felt sure they recognized the word but with no specific conscious recollection of the learning sequence. They were told to give a G response if they were not sure whether they had seen the word in the study list or not. After the recognition phase, they were asked to explain at least two of their Remember and two of their Know judgments to ensure that they had used them correctly. The dependent measures studied here were the number of hits minus false alarms for overall recognition and for R and K responses. Finally, participants took the 2-Back and Mill-Hill tests.

RESULTS

Executive Functions Analyses

There were significant differences in favor of the younger adults in the 2-Back test ($t(48) = 2.56, p = .014; M_{\text{young}} = 25.24$ and $M_{\text{old}} = 23.64$) and in the Stroop Color-Word Test ($t(48) = 4.77, p < .001; M_{\text{young}} = 10.23$ and $M_{\text{old}} = -3.44$). The difference was in the same direction in the Plus-Minus test ($M = 4.48$ and $M = 3.47$), but it failed to reach significance, $t(48) = 1.32, p = .20$.

Miyake et al. (2000) have claimed that complex executive functioning is underpinned by inhibition, shifting, and updating and that these functions share certain underlying features. Despite a pattern of relatively weak positive correlations computed at the level of the whole set of participants, overall it was consistent with Miyake et al.'s claim (see Table 1). However, the findings were somewhat mixed when considering the correlations within each age group. Whereas the correlations in the older group were in agreement with the analyses performed with the whole set of participants, those concerning the Stroop Color-Word Test appeared somewhat lower. Moreover, in the young adult group, we found that the 2-Back test score was correlated slightly negatively with the two other measures.

Given potential measurement error and for overlapping processes (Clarys et al., 2009), we created a “global” index of executive function. The data were reduced by running a principal component analysis (PCA) on the three neuropsychological test scores. One component with an eigenvalue greater than 1 was extracted from the factor analysis (47.3% of the variance). The three test scores loaded highly on the factor, indicating that they were relatively well represented by it. The factorial score, which was positively correlated with all the tests (see Table 1), was then referred to as a “global executive function measure,” with higher values denoting better performance. Importantly, t -test comparisons showed an age-related deficit on this executive function index, $t(48) = 4.2, p < .001$.

Remember/Know Paradigm Analyses

The mean hits minus false alarms and standard errors for overall recognition, Remember and Know responses are presented in Figures 1 and 2, respectively.

Firstly, to test the effect of animacy and aging on memory performances, separate analyses of variance (ANOVAs) were performed on these measures. Secondly, in order to test the involvement of executive functioning in the age-related deficit on recollection (R responses), we included as control variable the global executive function measure obtained from the PCA of the three tests measures. Given the between-groups discrepancies appearing on the correlations between these measures and the poor difference existing between young and old participants in the Plus-Minus test, this analysis was completed by separate analyses including as a control variable one of the executive function measure each in turn. If executive functions mediate the age-related deficit in recollection, as proposed by several authors (Bugaiska et al., 2007; Clarys et al., 2009), the interaction between age and animacy should not reach significance.

For the categorization task at encoding, the results showed that younger adults (animate: $M = 1101$ ms, $SD = 400$; inanimate: $M = 1086$ ms, $SD = 295$) categorized reliably faster than older adults (animate: $M = 1920$ ms, $SD = 541$; inanimate: $M = 1978$ ms, $SD = 605$),

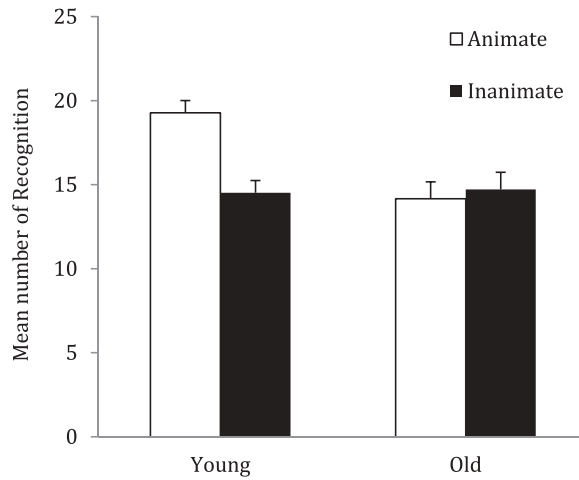


Figure 1. Mean numbers and standard errors of Recognition as a function of age (young versus older adults) and type of words (animate versus inanimate).

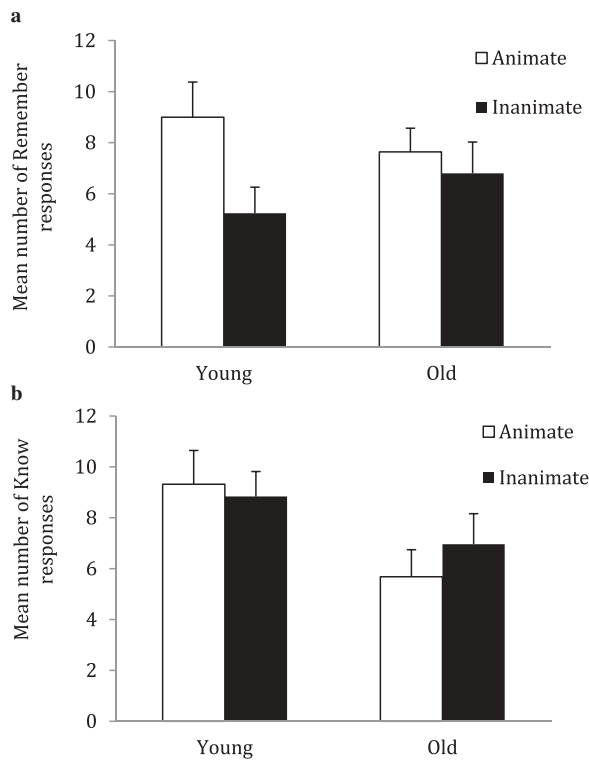


Figure 2. (a) Mean numbers and standard errors of (a) Remember and (b) Know responses as a function of age (young versus older adults) and type of words (animate versus inanimate).

$F(1, 48) = 45.7, p < .001, \eta^2_p = .49$. No effect of type of words appeared, $F(1, 48) = 0.24, p = .63, \eta^2_p = .005$, and no interaction between type of words and aging, $F(1, 48) = 0.64, p = .43, \eta^2_p = .01$.

Overall Recognition

The ANOVA on overall recognition indicated an effect of age, $F(1, 48) = 6.1, p = .017, \eta^2_p = .11$, showing that older adults recognized fewer words from the previously presented list than younger adults. A main effect of type of words appeared, $F(1, 48) = 7.92, p = .007, \eta^2_p = .14$, indicating that animate words were recognized better than inanimate words.

Finally, as illustrated by Figure 1, an interaction between age and type of words was observed, $F(1, 48) = 12.70, p < .001, \eta^2_p = .21$. For younger adults, t -test comparison indicated that animate words were recognized better than inanimate words, $t(24) = 5.14, p < .001$ ($M_{\text{animate}} = 19.28$ and $M_{\text{inanimate}} = 14.52$). For older adults, the difference between animate and inanimate words was not significant, $t(24) = -0.48, p = .64$ ($M_{\text{animate}} = 14.16$ and $M_{\text{inanimate}} = 14.72$).

Remember Responses¹

The ANOVA on R responses showed no reliable main effect of aging, $F(1, 48) = 0.004, p = .95, \eta^2_p < .001$, but revealed that the participants had more recollective experiences for animate than inanimate words, $F(1, 48) = 13.48, p < .001, \eta^2_p = .22$. The interaction between age and encoding condition was significant, $F(1, 48) = 5.43, p = .024, \eta^2_p = .10$.

As shown by Figure 2a, the animacy effect was stronger in young than in older adults. t -test comparisons showed that young adults recollected animate words better than inanimate words, $t(24) = 4.85, p < .001$ ($M_{\text{animate}} = 9$ and $M_{\text{inanimate}} = 5.24$). For older adults, the difference between animate and inanimate words was not significant, $t(24) = 0.85, p = .40$ ($M_{\text{animate}} = 7.64$ and $M_{\text{inanimate}} = 6.8$).

To test the involvement of executive functioning in the age-related deficit in recollection (R responses), we performed analyses of covariance (ANCOVAs) including firstly the global executive function index and secondly one of the executive function measures each in turn. The analyses including as covariates the scores obtained in the 2-Back test, the Stroop Color-Word Test, and the global executive function index all showed a same pattern of results. For this reason, only statistical results of the last analysis are reported. As illustrated in Figure 3, the main effect of aging was not significant, $F(1, 46) = 0.48, p = .49, \eta^2_p = .01$, and there was still a reliable effect of animacy with more animate words remembered than inanimate words, $F(1, 46) = 12.49, p < .001, \eta^2_p = .21$. Critically, the interaction effect between the two independent variables was no longer significant, $F(1, 46) = 0.63, p = .43, \eta^2_p = .01$. In addition, a significant interaction effect between the animacy dimension and the global executive function index was observed, $F(1, 46) = 4.74, p = .035, \eta^2_p = .09$, with subsequent animacy simple effects tests indicating that differences between animates and inanimates tend to increase with increasing executive function.

¹Recollection and familiarity can be computed in different ways. Thus, R/K responses are interpreted differently depending on the models considered; for instance, in models based on the Tulving's (1985) memory system, R responses are considered as episodic memory. Some authors have proposed a dual-process signal detection model in which Remember and Know responses are broken down into a discrete recollection component and a continuous familiarity component, respectively, based on an equal variance signal detection model (Yonelinas, Kroll, Dobbins, Lazzara, & Knight, 1998). In order to compare index data, we have computed two indices (one for recollection and one for familiarity) based on a dual-process signal detection model (Yonelinas et al., 1998). Analyses based on Recollection and Familiarity discrimination indices yielded the same pattern of results as analyses based on R and K responses.

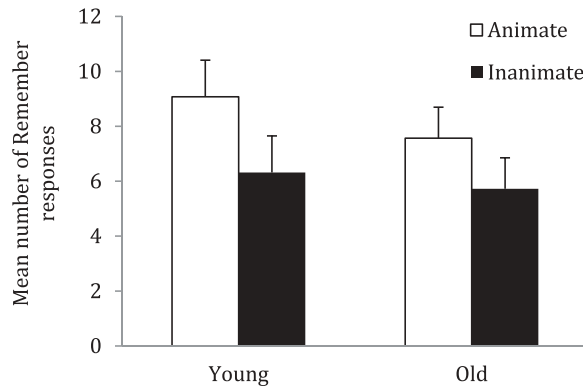


Figure 3. Adjusted mean numbers and standard errors of Remember responses as a function of age (young versus older adults) and type of words (animate versus inanimate) in the covariance analysis including the global executive function measure. Covariate is fixed at its mean value (0).

Global executive function index did not show a significant main effect, $F(1, 46) = 1.72$, $p = .20$, $\eta^2_p = .04$, nor interaction effects with aging (first order: $F(1, 46) = 0.18$, $p = .67$, $\eta^2_p = .004$; second order: $F(1, 46) = 0.33$, $p = .57$, $\eta^2_p = .004$).

Finally, when including as covariate the scores obtained in the Plus-Minus test, main or interaction effects including it were all unreliable and the results were thus the same as those obtained in the original ANOVA.

Know Responses

The analysis of K responses (Figure 2b) revealed that there was no reliable effect of age, $F(1, 48) = 3.29$, $p = .076$, $\eta^2_p = .06$, or type of words, $F(1, 48) = 0.48$, $p = .492$, $\eta^2_p = .01$, and that there was no reliable interaction between age and type of words, $F(1, 48) = 2.33$, $p = .134$, $\eta^2_p = .05$.

DISCUSSION

Previous studies on episodic memory have reported that animate items are remembered better than inanimate items (Bonin et al., 2014; Nairne et al., 2013; VanArtsdall et al., 2013). However, only young adults were involved in these studies. In the present study, we therefore addressed a simple question: Do healthy elders, like young adults, remember (to the same extent) animates better than inanimates? The present findings strongly suggest that they do not. However, the differential effect of animacy in young and older adults does not come as a surprise. In fact, in the introductory section, we described several lines of evidence suggesting that elders might not exhibit the animacy effect in memory to the same extent as young adults. For example, in a previous study, we found that animates were recognized better than inanimates (Bonin et al., 2014), and especially that the animacy effect was observed on Remember but not on Know responses. This pattern of findings supports the hypothesis that the animacy effect has an episodic nature. Because there is strong evidence that older people suffer from deficits in episodic memory (Bugaiska

et al., 2007; Bunce, 2003; Clarys et al., 2009; Perfect & Dasgupta, 1997), it was therefore anticipated that older people would exhibit a reduced animacy effect compared with young participants.

As explained in the introductory section, the survival processing advantage and the animacy effect are the two lines of evidence that currently support the adaptive memory view that postulates that the functional characteristics of our memory bear the imprints of evolutionary pressure faced by our ancestors in the distant past (Nairne, 2013). Previous studies investigating whether elders exhibit a survival processing advantage (Nouchi, 2012; Otgaar et al., 2015; Pandeirada et al., 2014; Stillman et al., 2014; Yang et al., 2014) have yielded mixed findings. However, given that none of these studies took executive functioning into account, age was confounded with the integrity of executive functions. There is evidence in the literature on memory and aging that a deficit in executive functions accounts for episodic memory decline (Bugajska et al., 2007; Clarys et al., 2009; Parkin & Walter, 1992). The strength of the present study is that we included measures of executive functions in our analysis, and that by so doing, the difference in the animacy effect between young and older adults found in the memory performance (in the R responses) vanished. This suggests that part of this effect is driven by executive functions.

Turning to the proximate mechanisms involved in the animacy effect in young adults, it should be pointed out that, to date, no study has explicitly and thoroughly addressed this issue. In the few papers that have reported animacy effects (Bonin et al., 2014; Nairne et al., 2013; VanArsdall et al., 2013), the underlying proximate mechanisms have only been alluded to. Nairne and colleagues envisioned the possibility that animate things are remembered well because they are particularly likely to capture attention (e.g., VanArsdall et al., 2013). Could the differential animacy effect in young and older adults be due to differences in attentional capture? Although this hypothesis is attractive, we do not think that it accounts for our findings because it has been shown, for example, that threat detection is not impaired among older adults (65–82) (Mather & Knight, 2006), although this was surely an adaptive feature in our ancestral past.

Finally, another possible explanation for the lack of a reliable animacy effect in elders is that it is due to adaptive changes that occur as a function of aging, namely, a shift away from the needs of reproduction and genetic transmission. Stillman et al. (2014) explained the finding that survival processing did not provide the same mnemonic benefit to healthy elders as to younger people by suggesting that the priorities and life goals of elders may differ from those of younger adults. According to the socioemotional selectivity theory of Carstensen (1992, 2006), older adults shift their priorities toward emotion regulation in order to enhance psychological well-being, and they deprioritize knowledge acquisition. This might explain their failure to take advantage of the rich encoding context of animates compared with inanimates. However, to validate this explanation, further studies are required to show that animates do indeed provide a richer encoding context than inanimates. Our finding that executive functions are involved in the animacy effect and account for its decline in elders does not run counter to the idea that older people may be less motivated to process animates and inanimates differently (e.g., because if they detect a predator they are less able to fight or flee; because they are less motivated to find a sexual partner) and hence show greater difficulty initiating differential memory mechanisms to process animates. As discussed in the introductory section, the hypothesis of the decline of executive function in episodic memory in older people postulates that they are less able to initiate and use appropriate strategies at encoding and recognition to improve the memory trace (Bugajska et al., 2007; Clarys et al., 2009).

To conclude, do healthy elders, like young adults, remember (to the same extent) animates better than inanimates? The answer is “no” and this can be attributed to a decline in executive functions.

FUNDING

This work was supported by a grant from the Institut Universitaire de France to the third author.

REFERENCES

- Bonin, P., Gelin, M., & Bugaiska, A. (2014). Animates are better remembered than inanimates: Further evidence from word and picture stimuli. *Memory & Cognition, 42*, 370–382. doi: [10.3758/s13421-013-0368-8](https://doi.org/10.3758/s13421-013-0368-8)
- Bonin, P., Peereman, R., Malardier, N., Méot, A., & Chalard, M. (2003). A new set of 299 pictures for psycholinguistic studies: French norms for name agreement, image agreement, conceptual familiarity, visual complexity, image variability, age of acquisition, and naming latencies. *Behavior Research Methods, Instruments, & Computers, 35*, 158–167. doi: [10.3758/BF03195507](https://doi.org/10.3758/BF03195507)
- Bugaiska, A., Clarys, D., Jarry, C., Taconnat, L., Tapia, G., Vanneste, S., & Isingrini, M. (2007). The effect of aging in recollective experience: The processing speed and executive functioning hypothesis. *Consciousness and Cognition, 16*, 797–808. doi: [10.1016/j.concog.2006.11.007](https://doi.org/10.1016/j.concog.2006.11.007)
- Bunce, D. (2003). Cognitive support at encoding attenuates age differences in recollective experience among adults of lower frontal lobe function. *Neuropsychology, 17*, 353–361.
- Carstensen, L. L. (1992). Social and emotional patterns in adulthood: Support for socioemotional selectivity theory. *Psychology and Aging, 7*, 331–338. doi: [10.1037/0882-7974.7.3.331](https://doi.org/10.1037/0882-7974.7.3.331)
- Carstensen, L. L. (2006). The influence of a sense of time on human development. *Science, 312*, 1913–1915. doi: [10.1126/science.1127488](https://doi.org/10.1126/science.1127488)
- Clarys, D., Bugaiska, A., Tapia, G., & Baudouin, A. (2009). Ageing, remembering and executive function. *Memory, 17*, 158–168. doi: [10.1080/09658210802188301](https://doi.org/10.1080/09658210802188301)
- Craik, F. I. M., & Salthouse, T. A. (Eds.) (2008). *The handbook of aging and cognition* (3rd ed.). New York, NY: Psychology Press.
- Deltour, J. J. (1993). *Echelle de vocabulaire de Mill Hill de J.C. Raven. Adaptation française et normes européennes du Mill Hill et du Standard Progressive Matrices de Raven (PM38)*. Braine-le-Chateau, France: Editions l'application des techniques modernes.
- Folstein, M., Folstein, S., & McHugh, P. (1975). Mini-Mental State: A practical method for grading the mental state of patients for the clinician. *Journal of Psychiatric Research, 12*, 189–198. doi: [10.1016/0022-3956\(75\)90026-6](https://doi.org/10.1016/0022-3956(75)90026-6)
- Gardiner, J. M. (1988). Functional aspects of recollective experience. *Memory & Cognition, 16*, 309–313. doi: [10.3758/BF03197041](https://doi.org/10.3758/BF03197041)
- Gevins, A., & Cutillo, B. (1993). Spatiotemporal dynamics of component processes in human working memory. *Electroencephalography and Clinical Neurophysiology, 87*, 128–143. doi: [10.1016/0013-4694\(93\)90119-G](https://doi.org/10.1016/0013-4694(93)90119-G)
- Glisky, E. L. (2007). Changes in cognitive function in human aging. In D. Riddle (Ed.), *Brain aging: Methods, models, and mechanisms* (pp. 3–20). New-York: CRC Press.
- Jersild, A. T. (1927). Mental set and shift. *Archives of Psychology, 89*, 5–82.
- Mather, M., & Knight, M. R. (2006). Angry faces get noticed quickly: Threat detection is not impaired among older adults. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 61*, 54–57. doi: [10.1093/geronb/61.1.P54](https://doi.org/10.1093/geronb/61.1.P54)

- Miyake, A., Friedman, N., Emerson, M., Witzki, A., Howerter, A., & Wager, T. (2000). The unity and diversity of executive functions and their contributions to complex frontal lobe tasks: A latent variable analysis. *Cognitive Psychology*, *41*, 49–100. doi: [10.1006/cogp.1999.0734](https://doi.org/10.1006/cogp.1999.0734)
- Moscovitch, M., & Winocur, G. (1992). The neuropsychology of memory and aging. In F. I. M. Craik & T. A. Salthouse (Eds.), *The handbook of aging and cognition* (pp. 315–371). Hillsdale, NJ: Erlbaum.
- Nairne, J. S. (2010). Adaptive memory: Evolutionary constraints on remembering. In B. H. Ross (Ed.), *The psychology of learning and motivation* (Vol. 53, pp. 1–32). Burlington, MA: Academic Press.
- Nairne, J. S. (2013). Adaptive memory: Controversies and future directions. In B. L. Schwartz, M. L. Howe, M. P. Toglia, & H. Otgaar (Eds.), *What is adaptive about adaptive memory?* (pp. 308–321). New York: Oxford University Press.
- Nairne, J. S., & Pandeirada, J. N. S. (2008a). Adaptive memory: Remembering with a stone-age brain. *Current Directions in Psychological Science*, *17*, 239–243. doi: [10.1111/j.1467-8721.2008.00582.x](https://doi.org/10.1111/j.1467-8721.2008.00582.x)
- Nairne, J. S., & Pandeirada, J. N. S. (2008b). Adaptive memory: Is survival processing special? *Journal of Memory and Language*, *59*, 377–385. doi: [10.1016/j.jml.2008.06.001](https://doi.org/10.1016/j.jml.2008.06.001)
- Nairne, J. S., Thompson, S. R., & Pandeirada, J. N. S. (2007). Adaptive memory: Survival processing enhances retention. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *33*, 263–273.
- Nairne, J. S., VanArsdall, J. E., Pandeirada, J. N. S., Cogdill, M., & LeBreton, J. M. (2013). Adaptive memory: The mnemonic value of animacy. *Psychological Science*, *24*, 2099–2105. doi: [10.1177/0956797613480803](https://doi.org/10.1177/0956797613480803)
- Nouchi, R. (2012). The effect of aging on the memory enhancement of the survival judgment task. *Japanese Psychological Research*, *54*, 210–217. doi: [10.1111/jpr.2012.54.issue-2](https://doi.org/10.1111/jpr.2012.54.issue-2)
- Otgaar, H., Jelicic, M., & Smeets, T. (2015). Adaptive memory: Identifying the proximate roots of the survival processing advantage. *The Journal of Psychology: Interdisciplinary and Applied*, *149*, 339–355. doi: [10.1080/00223980.2013.879848](https://doi.org/10.1080/00223980.2013.879848)
- Pandeirada, J. N. S., Pinho, M. S., & Faria, A. L. (2014). The mark of adaptive memory in healthy and cognitively impaired older adults and elderly. *Japanese Psychological Research*, *56*, 168–179. doi: [10.1111/jpr.12040](https://doi.org/10.1111/jpr.12040)
- Parkin, A. J. (1997). Normal age-related memory loss and its relation to frontal lobe dysfunction. In P. Rabbitt (Ed.), *Methodology of frontal and executive function* (pp. 177–190). Hove, UK: Psychology Press.
- Parkin, A. J., & Walter, B. M. (1992). Recollective experience, normal aging, and frontal dysfunction. *Psychology and Aging*, *7*, 290–298. doi: [10.1037/0882-7974.7.2.290](https://doi.org/10.1037/0882-7974.7.2.290)
- Perfect, T. J., & Dasgupta, Z. R. R. (1997). What underlies the deficit in reported recollective experience in old age? *Memory & Cognition*, *25*, 849–858. doi: [10.3758/BF03211329](https://doi.org/10.3758/BF03211329)
- Raz, N. (2000). Aging of the brain and its impact on cognitive performance: Integration of structural and functional findings. In F. I. M. Craik & T. A. Salthouse (Eds.), *The handbook of aging and cognition*. (2nd ed.). London: Lawrence Erlbaum Associates Publishers.
- Snodgrass, J. C., & Vanderwart, M. (1980). A standardized set of 260 pictures: Norms for names agreement, image agreement, familiarity, and visual complexity. *Journal of Experimental Psychology: Human Learning & Memory*, *6*, 174–215.
- Spector, A., & Biederman, I. (1976). Mental set and mental shift revisited. *The American Journal of Psychology*, *89*, 669–679. doi: [10.2307/1421465](https://doi.org/10.2307/1421465)
- Stillman, C. M., Coane, J. H., Profaci, C. P., Howard, J. H., & Howard, D. V. (2014). The effects of healthy aging on the mnemonic benefit of survival processing. *Memory & Cognition*, *42*, 175–185. doi: [10.3758/s13421-013-0353-2](https://doi.org/10.3758/s13421-013-0353-2)
- Stroop, J. R. (1935). Studies of interference in serial verbal reactions. *Journal of Experimental Psychology*, *89*, 669–679.
- Tulving, E. (1985). Memory and consciousness. *Canadian Psychology/Psychologie Canadienne*, *26*, 1–12. doi: [10.1037/h0080017](https://doi.org/10.1037/h0080017)
- VanArsdall, J. E., Nairne, J. S., Pandeirada, J. N. S., & Blunt, J. R. (2013). Adaptive memory: Animacy processing produces mnemonic advantages. *Experimental Psychology*, *60*, 172–178. doi: [10.1027/1618-3169/a000186](https://doi.org/10.1027/1618-3169/a000186)

- West, R. L. (1996). An application of prefrontal cortex function theory to cognitive aging. *Psychological Bulletin*, *120*, 272–292. doi: [10.1037/0033-2909.120.2.272](https://doi.org/10.1037/0033-2909.120.2.272)
- Yang, L., Lau, K. P. L., & Truong, L. (2014). The survival effect in memory: Does it hold into old age and non-ancestral scenarios? *PLoS ONE*, *9*, e95792. doi: [10.1371/journal.pone.0095792](https://doi.org/10.1371/journal.pone.0095792)
- Yonelinas, A. P. (2002). The nature of recollection and familiarity: A review of 30 years of research. *Journal of Memory and Language*, *46*, 441–517. doi: [10.1006/jmla.2002.2864](https://doi.org/10.1006/jmla.2002.2864)
- Yonelinas, A. P., Kroll, N. E. A., Dobbins, I., Lazzara, M., & Knight, R. T. (1998). Recollection and familiarity deficits in amnesia: Convergence of remember-know, process dissociation, and receiver operating characteristic data. *Neuropsychology*, *12*, 323–339. doi: [10.1037/0894-4105.12.3.323](https://doi.org/10.1037/0894-4105.12.3.323)