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Why Humor's Positive Effect on Memory Disappears With Aging

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Numerous studies have highlighted the beneficial effect of humor on memory in younger adults. While older adults are known to preferentially process positive information and appreciate humor, no study has investigated whether the effect of humor on memory persists in aging. Two studies were conducted to address this gap. In Study 1, 19 younger adults and 20 older adults performed a memory task designed to compare the recall of humorous and neutral photograph sequences. Results revealed the typical beneficial effect of humor on free recall in young adults, while in older adults, humor had no influence on free recall and even a detrimental effect in the cued recall task, suggesting that humor primarily affects encoding processes. Study 2 aimed to replicate these findings and further investigate the mechanisms underlying this negative effect in older adults (i.e., the effect of humor per se or confounding incongruity effect). To this end, 37 younger adults and 38 older adults completed a similar task, now featuring three different photograph sequences (humorous, incongruous and neutral). Older adults exhibited no further effect of humor on memory when incongruity was controlled, whereas younger adults continued to recall humorous photographs better than neutral ones, in the two retrieval conditions. As expected, older adults also showed a negative effect of incongruity on memory, consistent with the inefficiency of their binding processes. Taken together, these studies show that the positive effect of humor on memory disappears in aging, owing to the inherent incongruity of humorous stimuli, combined with an associative memory deficit.

Keywords: humor, memory, aging, incongruity, associative memory

In recent decades, many studies have focused on the link between emotion and memory, identifying the conditions under which memory performance is enhanced. More recently, a new way of looking at positive and high-arousal emotions has emerged, with the development of research focusing on humor (Kennison, 2020). This research has demonstrated a positive effect of humor on memory, with better performances for humorous items than for neutral ones (e.g., Takahashi & Inoue, 2009). However, no studies have so far tested whether this effect persists in aging and whether humor can compensate for the age-related decrease in memory abilities, which is classically attributed to an associative memory deficit (Naveh-Benjamin & Kilb, 2014). The aim of the present research was therefore to test, through two successive studies, whether the positive impact of humor on memory persists in aging and to identify the mechanisms behind the effects of humor on memory.

Humor is a ubiquitous phenomenon with various definitions, and the sense of humor itself is not a singular concept, since it encompasses social, developmental, emotional, cognitive, and biological dimensions, all of which interact (Greengross, 2013). Based on Martin and Ford's study (2018), humor can be defined as follows:

> Humor is an extensive, multifaceted concept, encompassing any actions or words perceived as funny by others, often leading to laughter. This includes both the mental processes involved in creating and interpreting humorous stimuli and the emotional response of mirth associated with their enjoyment. (Martin & Ford, 2018, p. 3)

Recent advancements in humor research have provided significant insights into humor's multifaceted contributions to cognitive and emotional functioning. Research has demonstrated its positive impact on interpersonal relationships and highlighted its essential role in psychological health and well-being (Ford et al., 2016; Wellenzohn et al., 2018). Moreover, humor has been shown to enhance cognitive functions and particularly memory. Nearly all studies investigating humor's impact on memory have been

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conducted among young adults, generally demonstrating a beneficial effect of humorous items compared to neutral ones on subsequent memory performances whether in education (Kaplan & Pascoe, 1977; Zillmann et al., 1980; Ziv, 1988), advertising (for a review, see Eisend, 2018), or experimental psychology (e.g., Takahashi & Inoue, 2009). The effect occurs regardless of medium (sentences: Carlson, 2011; Schmidt, 1994; cartoons and photographs with humorous labels: Carlson, 2011; Chambers & Payne, 2014; Schmidt, 2002; Schmidt & Williams, 2001; Takahashi & Inoue, 2009) and retrieval task (free or cued recall; Schmidt, 1994). Furthermore, the positive effect of humor not only concerns the humorous items themselves but also extends to their context, suggesting that like other high-arousal and positive emotions, humor improves associative memory performance (Madan et al., 2019; Mather & Nesmith, 2008). Mickes et al. (2012) observed that young adults not only recognize funny captions better than nonfunny ones but also remembered the gender of the person who produced the captions better when the captions are humorous.

Several hypotheses were proposed to explain the beneficial effect of humor on memory (Carlson, 2011; Martin & Ford, 2018; Schmidt, 1994, 2002). First, it was put forward that humor would cause a surprise effect, leading to an attraction of attention toward humorous material. This increased attention would, in turn, enhance the memorization of the humorous material. However, even when participants were warned that they were going to deal with humorous sentences, the humor effect persisted (Schmidt, 1994). It was also suggested that the arousal nature of humorous items could be responsible for this effect. Indeed, the arousal items, whatever the valence, would trigger an activation of the amygdala. This one would modulate the activity of the hippocampus, enabling better encoding and retention of arousal items at the expense of neutral items (LaBar & Cabeza, 2006). In terms of cognitive processes, arousal items would be more distinct from others and would capture attention during encoding (Sommer et al., 2008). While emotional arousal undoubtedly contributes to the enhancement of emotional memory, it is not the sole factor, as it does not account for the lack of a humor effect observed in between-subjects designs (Schmidt, 1994).

For others, the humorous material would be rehearsed more often than nonhumorous material, which might explain the advantage observed toward humorous material. The fact is that the humor effect is stronger in intentional than in incidental encoding. Nevertheless, it is still observable in the latter condition, which permits to only partially validate this hypothesis. Finally, it is probably the incongruity hypothesis that explains the humor effect best. Incongruity can be defined as the simultaneous presence of incompatible or incoherent elements in a situation (Martin, 2007). According to the widely accepted incongruity-resolution theory of humor comprehension (Suls, 1972), humor arises through a two-step process. The first step involves detecting an incongruity between the presented information and the expectations shaped by the storyline. This discrepancy between the content of the punchline's context and the expected outcomes triggers a reaction of surprise, but not yet amusement. Understanding the joke requires moving beyond this initial surprise and constructing a new, coherent interpretation of the situation. This cognitive elaboration constitutes the second stage of Sul's model, involving the resolution of incongruity by identifying a rule or framework that reconciles the incoherent information with the initial context in a way that is both logical and unexpectedly amusing. It is this resolution of incongruity that elicits laughter. Conversely, when an individual is unable to resolve the incongruity, they remain perplexed and unable to perceive the comic nature of the situation. Based on the distinctiveness theory in memory, Schmidt (1994) emphasized two levels of incongruity in paradigms leading to a humor effect on memory. The item distinctiveness would link to the intrinsic characteristics of humorous items. Indeed, to understand these items, it is necessary to resolve the incongruity (it is this incongruity which makes the humorous item). This work requests to pay an increased attention toward humorous stimuli. The second level of incongruity, called relational distinctiveness, refers to the fact that humorous items are clearly distinguishable from nonhumorous items in within-subjects designs.

To the best of our knowledge, only one study has so far investigated how humor impacts memory in older adults (Bains et al., 2014). Participants either watched a humorous video or just sat calmly. They then performed a word-list learning task with no emotional content (Rey Auditory Verbal Learning Test). Results showed that older adults learned better after watching a humorous video than in the control condition. These results suggest that older adults' memory can still be positively influenced by humor, but three main limitations reduce their scope. First, the study was limited to older adults, and no younger participants were included, making it impossible to draw any conclusions about how aging affects the effect of humor on memory. Second, humor was used here solely as a way of inducing a positive mood, and the study did not assess either the recall of humorous items or participants' associative memory, which is most sensitive to age-related decline. Third, the sample size was very small (10 participants per condition) and participants were not blind to their assigned condition (experimental or control). There is therefore a wide gap in literature regarding the persistence of humor's effect on memory in aging, despite its importance. Addressing this question may help identify the conditions under which age-related deficits in cognitive functioning are present or absent (Rotolo et al., 2024), shed light on the interaction between emotional and cognitive processes, and clarify the mechanisms underpinning humor in older adults. This, in turn, would help determine whether the flourishing humor-based interventions aimed at enhancing cognition and well-being in older adults are truly well-suited (Gonot-Schoupinsky & Garip, 2018).

There are several reasons why older people should be particularly sensitive to the effects of humor on memory. First, emotional enhancement of memory (EEM; i.e., better recall of emotional vs. neutral items) has been observed in aging (Denburg et al., 2003; Kensinger et al., 2002) for positive items (Mather & Carstensen, 2005). This so-called *positivity effect* refers to preference for positive over negative material in older adults (Reed & Carstensen, 2012). However, this effect is not always observed and varies according to the material, the type of measurements, and probably the study design (Hess et al., 2013; Murphy & Isaacowitz, 2008). In particular, Hess et al. (2013) highlighted that the positivity effect was observed for nonsocial stimuli but not for social stimuli (i.e. stimuli containing people). In contrast, for social stimuli, the authors found a negativity bias regardless of age group (younger or older adults). This result was interpreted as reflecting subjects' empathy for difficult situations (negative social images evoking sadness or suffering, for example) or engaging self-referential processes of stimuli. One of the theories proposed to explain the preferential processing of positive over negative material in older adults is the socioemotional selectivity theory (Carstensen, 2006). According to this theory, older adults would have a limited time perspective compared with younger adults, which would lead to a change in their motivation and their goals in favoring present-oriented goals and therefore immediate satisfaction. Thus, older adults would tend to focus more on positive than negative information. However, the classical positive effect of humor on memory did not fit neatly within this theoretical framework, as it describes a benefit for humorous items compared to neutral items—a comparison that aligns more closely with what Murphy and Isaacowitz (2008) referred as *positivity preference*. This last effect is not specific to normal aging, as it is observed in both young and older adults. However, the magnitude of the positivity effect varies according to the type of measurement and, likely, the experimental design and is not consistently found across studies, indicating a lack of consistency in the literature (Grühn et al., 2005). For example, the positivity preference is more likely to emerge in recall rather than recognition paradigms (Murphy & Isaacowitz, 2008). First demonstrated in single-item memory paradigms, this memory enhancement due to positive emotion has also been recently observed in associative memory (Madan et al., 2019). This result is particularly interesting, as one of the main hypotheses put forward to explain the episodic memory decline in normal aging targets associative memory (Naveh-Benjamin & Kilb, 2014). According to the *associative deficit hypothesis* (Naveh-Benjamin, 2000), older adults' difficulty creating rich memories is caused by impairments in both the binding of the different features during encoding and their subsequent retrieval. Positive emotional content could therefore be a good means of minimizing this associative deficit. It should be noted that valence is not the only factor that can modulate the intensity of EEM (Russell, 1980, 2003), as arousal (ranging from calm to excited) is also a critical factor. Better memory performances have been observed for highly versus weakly arousing stimuli (Cahill & McGaugh, 1998). As far as associative memory is concerned, in spite of mixed results, Nashiro and Mather (2011) showed that not only were arousing items better remembered than nonarousing ones but also the features associated with these same items (e.g., their location) were also better remembered, by both older adults and young people.

Thus, if EEM has been highlighted for both positive and highly arousing stimuli in associative memory tasks among older individuals, it should also be observable with humorous stimuli. Humorous items often lead to the emotion of mirth, which is associated with increased activity of the sympathetic nervous system (Cacioppo et al., 2000). Using humor with older adults seems particularly appropriate for investigating the link between emotion and memory (see Greengross, 2013, for a review). Older adults are able to differentiate between humorous and neutral statements just as well as younger adults (Shammi & Stuss, 2003). They also enjoy humorous situations and report being amused when they come across humorous statements or cartoons (e.g., Vieillard & Pinabiaux, 2019), even if they have reduced facial expressiveness (absence of increased electromyographic activity over zygomaticus for humorous items, unlike younger people). The spontaneous physiological change (i.e., increased skin conductance level) elicited by humorous versus neutral cartoons is also similar in both older and younger adults, and older adults can even use extrinsic humorous emotion regulation as effectively as young adults (Harm et al., 2014). Humor could therefore be a useful means of compensating for age-related deficits in memory.

Present Research

In sum, prior investigations have largely described a memory bias in favor of humorous information in young adults (Carlson, 2011; Schmidt, 1994, 2002; Schmidt & Williams, 2001; Takahashi & Inoue, 2009). To date, no study has yet examined whether this advantage persists in aging. As older adults generally exhibit a positivity effect (e.g., Mather & Carstensen, 2005) and particularly appreciate humor (Greengross, 2013), this advantage may well persist. The present study therefore had a twofold purpose: (a) to examine whether the beneficial effect of humor on memory persists in older adults and (b) to test whether the effect of humor can offset age-related associative memory decline. To this end, we created an original task and administered it to younger and older adults. Humorous and neutral photographs were incidentally encoded in a funniness judgment task, and memory was then tested in free and cued recall tasks, in order to disentangle encoding from retrieval processes. Given the beneficial effect of humor on memory previously observed in younger adults (e.g., Schmidt, 1994, 2002; Schmidt & Williams, 2001), we expected younger adults to recall more humorous photographs than neutral ones. Concerning older adults, we expected them to particularly appreciate the humorous photographs and to recall them better than the neutral ones. Three arguments supported these expectations: (a) aging is characterized by a positivity preference which implies that older adults should be sensitive to humorous stimuli (e.g., Carstensen & DeLiema, 2018; Reed et al., 2014); (b) older adults particularly appreciate humorous items (e.g., Greengross, 2013); and (c) the only study to have been carried out in normal aging showed that memory in older adults can be positively impacted by humor (Bains et al., 2014).

Study 1

Method

Participants

Power analysis was conducted to determine the required sample size. As no study had previously been conducted on the age-related effect of humor on associative memory, sample size was based on (a) the effect of humor on memory in young adults (Summerfelt et al., 2010; Cohen's $d = 0.80$); (b) the results of a meta-analysis concerning age-related decline in associative memory measures (Old & Naveh-Benjamin, 2008; Cohen's $d = 0.92$); and (c) the mean effect size for positive preference effect in aging according to a meta-analysis (Murphy & Isaacowitz, 2008; $d = 0.48$). Therefore, we based our sample size on the most demanding conditions, that is, the effect of the smallest size ($d = 0.48$). Using G*Power 3.1.9.4, with $\alpha = .05$, an effect size of $d = 0.48$, and a power of .80, the total recommended sample size was 38. We decided to include just over 20 participants in each age group, given the possibility that some participants, particularly older ones, might show abnormal cognitive functioning in the neuropsychological assessment, which could prevent them from being included.

We recruited 43 adults in Spring 2021 (20 younger adults and 23 older adults). None of them reported a history of neurological or psychiatric illness. A general neuropsychological assessment was used to exclude participants with atypical cognitive functioning or anxiety and depressive symptoms. Global cognitive functioning was assessed with the Mini-Mental State Examination

(Folstein et al., 1975; Kalafat et al., 2003), episodic memory with the Free and Cued Recall Selective Reminding Test (Van der Linden et al., 2004), semantic memory with a naming test (30-item oral picture naming task; Binetruy et al., 2018; Ferreira et al., 2010), inhibition with the Stroop test (Golden, 1978), flexibility with the Trail Making Test (TMT; Binetruy et al., 2018; Ferreira et al., 2010), and processing speed with the TMT Part A (Binetruy et al., 2018; Ferreira et al., 2010). Volunteers were excluded if at least two of the above scores were below the fifth percentile. The State-Trait Anxiety Inventory–Y (Spielberger et al., 1983) and the Patient Health Questionnaire–9 (PHQ-9; Kroenke et al., 2001) were used to assess anxiety and depressive symptoms. Any participants with scores above the cutoff were excluded (State-Trait Anxiety Inventory–Y trait scores >65; Patient Health Questionnaire–9 raw scores >19). Three participants were excluded as a result. Moreover, a fourth participant was excluded because of recording problems during the humor associative task.

The final sample comprised 39 French participants: 19 younger adults (M_{age} = 22.684 years, SD_{age} = 2.335; nine men, 10 women) and 20 older adults (M_{age} = 75.5 years, SD_{age} = 9.058; four men, 16 women; see Appendix A for a complete description of participants' characteristics). Statistical analyses (*t* tests, Welch's test, or Mann–Whitney *U* test, depending on normality of data distribution and homogeneity of variances) revealed that older adults did not differ from younger adults in terms of global functioning (Mini-Mental State Examination, p = .134) or depressive symptoms (Patient Health Questionnaire–9, p = .14). Nonetheless, and as usually described in the literature, the older participants scored lower on tasks assessing episodic memory (Free and Cued Recall Selective Reminding Test, $p < .001$), inhibition (Stroop, $p < .001$), flexibility (TMT B-A, p = .005), processing speed (TMT A, $p < .001$) and anxiety (State-Trait Anxiety Inventory, p = .005) and higher on task assessing semantic memory (30-item oral picture naming task 30, p = .049).

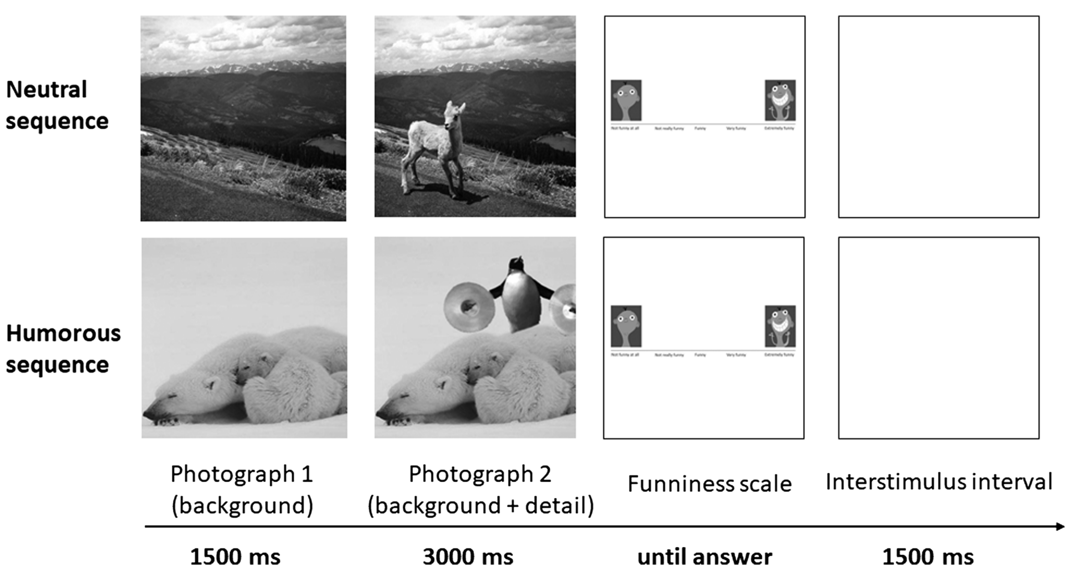
All the participants took part on a voluntary basis and gave their written informed consent, in compliance with the Declaration of Helsinki. The study was conducted in accordance with French legislation on personal data protection and patient information in the case of noninterventional research.

Material and Procedure

Humor Associative Test. We used 20 minisequences of two photographs that had previously been used by Schwartz et al. (2008). The first photograph depicted a neutral background (e.g., landscape, road, room). The second one was nearly the same but had one extra detail (see Figure 1). For half the sequences (i.e., humorous sequences), the added detail made the picture funny, whereas for the other half (i.e., neutral sequences), the picture remained neutral. One humorous sequence and one neutral sequence were used for training, and the remaining 18 were used in the encoding phase. To make the distinction between the training and encoding sequences clearer for participants, the two training sequences comprised color photographs, whereas the others comprised black-and-white photographs. The two types of sequences (i.e., humorous vs. neutral) were matched on content: five sequences featured animals (nonsocial stimuli) and four featured humans (social stimuli; see Appendix B for the verbal description and image statistics of the photographs). Photographs each measured 3.6 × 3.6 inches and were displayed in the center of a 17-inch laptop using E-Prime 2.0 software (Psychology Software Tools, Pittsburgh, Pennsylvani). As some of the material used in this study came from a study carried out by other researchers (Schwartz et al., 2008), we are

Figure 1

Example of Sequences of Photographs Used in Encoding Phase



Note. Adapted from the material used in "Abnormal Activity in Hypothalamus and Amygdala During Humour Processing in Human Narcolepsy With Cataplexy," by S. Schwartz, A. Ponz, R. Poryazova, E. Werth, P. Boesiger, R. Khatami, and C. L. Bassetti, 2008, *Brain: A Journal of Neurology*, *131*(2) (https://doi.org/10.1093/brain/awm292). Copyright 2008 by The Author(s). Adapted with permission.

unable to directly share the material and invite interested parties to contact these authors directly.

Incidental Encoding Phase. Participants were asked to look carefully at the sequences of pictures displayed in the center of the screen. After each sequence, they had to rate how funny the sequence was on a 5-point Likert scale similar to the one used by Schwartz et al. (2008), ranging from 1 (*not funny at all*) to 5 (*extremely funny*). The subsequent retrieval phase was not mentioned. Before beginning the task and processing the 18 experimental sequences, participants were provided with an explanation of the task and completed two training sequences: one humorous and one neutral. These sequences supported the instructions and allowed the experimenter to explain both the task and the use of the Likert scale. There was no time constraint for these training sequences. At the end of the two examples, the experimenter asked participants if the instructions were clear, if they needed additional training, or if they had any questions. None of the participants required further examples. During the task itself, the first photograph (i.e., background) was displayed for 1,500 ms and the second one (i.e., background + detail) for 3,000 ms. The 5-point Likert scale was then displayed and remained on the screen until the participant had given a verbal answer. The experimenter pressed the corresponding key, and a white screen was then displayed for a 1,500-ms interstimulus interval. These durations were determined on the basis of pretests, which revealed the necessity of keeping the first photograph's display brief to maintain participants' focus on the task, while allowing a longer viewing time for the second photograph. The extended duration for the second photograph was required due to the more complex processes involved, including detecting additional details and attempting to resolve incongruities in the case of humorous sequences. The 18 sequences were shown in a random order (i.e., different for each participant).

Retrieval Phase. After 2 min dedicated to the Self-Assessment Manikin (Bradley & Lang, 1994) and a 45-s time-limited version of the Stroop test (Golden, 1978), the unexpected retrieval phase began. Participants were asked to verbally recall as many previously encoded pictures as possible. They had to be as precise as possible, so that their description would allow us to distinguish the evoked picture from the other encoded pictures. If 15 s elapsed without an answer, we gave a general prompt. The free recall phase ended after two general prompts or after 2 min. Answers were recorded and then faithfully written down to allow for blind coding later on. A cued recall task was then administered. For each of the 18 encoded sequences, participants were shown the first picture (background) and had to recall the missing detail. The 18 pictures were shown in a new random order from that used during presentation and different random orders for each participant.

Scoring. Three scores were calculated for each type of sequence (neutral vs. humorous): two free recall scores (an associative score and a detail score) and one cued recall score. The Associative score corresponded to the number of sequences correctly recalled in their entirety (i.e., background + associated detail; e.g., "polar bears sleeping + a penguin with cymbal above them"; maximum = 9). As for the detail free recall score, it focused on the recall of the second photograph; 1 point was awarded if the main element of the second photograph was recalled (e.g., "a penguin with cymbals"). Only 1 point could thus be assigned per sequence, leading to a maximum score of 9. Finally, the detail cued recall score was also based on the number of times a participant recalled the detail from the second photograph recalled, but it referred to a different retrieval phase, namely the cued recall phase (maximum = 9). A double-scoring method was implemented for more than 20% of the scores (nine participants). It revealed an agreement rate of approximately 96% (10 discrepancies out of 324 scoring during free recall and nine discrepancies out of 162 scoring during cued recall). Discrepancies were discussed until a consensus was reached and strict scoring rules specifically adapted to the material were established. Based on these even more specific rules, the responses of the other participants were then evaluated by just one of the evaluators.

Transparency and Openness

We report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study. All data have been made publicly available via the Open Science Framework at https://doi.org/10.17605/OSF.IO/RNXMW. Since the material used in this study is mostly sourced from the work of other researchers (Schwartz et al., 2008), we are not in a position to directly share this material. We invite interested parties to contact the original researchers directly for access to the material. Data were analyzed using JASP 0.19.3. This study's design and its analysis were not preregistered.

Results

Statistical Analysis

First, we focused on variations in funniness judgments in the encoding phase. More specifically, we ran analyses of variance (ANOVAs) on the funniness ratings according to group (younger adults vs. older adults) and sequence type (neutral vs. humorous). Second, we tested the impact of sequence type on memory by running a series of ANOVAs with age group (younger adults vs. older adults) as a between-group factor and sequence type (neutral vs. humorous) as a within-group factor. Analyses were successively conducted on the two free recall scores (i.e., detail free recall and associative scores) and on the detail cued recall score. Effect sizes were estimated through η^2 tests in ANOVA, and Cohen's d was employed when contrasts were conducted to further explore significant interactions.

Encoding Phase

The mixed ANOVA conducted on funniness ratings revealed significant main effects of sequence type, as participants generally rated humorous sequences as funnier than neutral ones, $F(1, 37) = 226.012$, $p < .001$, $\eta^2 = .552$. It also revealed a significant age group effect, with older adults rating the sequences as funnier than younger adults, $F(1, 37) = 53.68$, $p < .001$, $\eta^2 = .189$. These findings must be interpreted in the context of the interaction between age and sequence type, $F(1, 37) = 15.6$, $p < .001$, $\eta^2 = .038$: both groups rated humorous sequences as funnier than neutral ones ($t_{\text{Older adults}} = 7.94$, $p < .001$, $d = 2.272$; $t_{\text{Younger adults}} = 13.255$, $p < .001$, $d = 3.981$) and older participants consistently rated the sequences funnier than younger adults, but this difference was more pronounced for neutral sequences ($t = 8.554$, $p < .001$, $d = 2.613$) than for humorous ones ($t = 2.972$, $p = .005$, $d = 0.994$; see Table 1).

Table 1
Mean Funniness Ratings (Standard Deviations) According to Sequence Type and Age Group in Study 1

Sequence type	Younger adult	Older adult
Humorous	3.01 (0.46)	3.46 (0.48)
Neutral	1.25 (0.30)	2.43(0.52)

Note. All differences were significant (all *p*s < .001).

Free Recall Phase

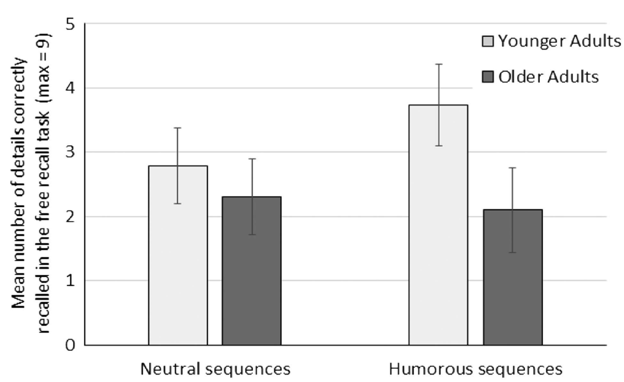
The mixed ANOVA conducted on the detail free recall score failed to reveal a main effect of sequence type, $F(1, 37) = 2.29$, $p = .14$, $\eta^2 = .017$. It did, however, reveal a main effect of age group, $F(1, 37) = 10.09$, $p = .003$, $\eta^2 = .141$, and a significant interaction between these factors, $F(1, 37) = 5.38$, $p = .026$, $\eta^2 = .041$ (see Figure 2): the younger adults correctly recalled more humorous pictures than neutral ones ($t = 2.675$, $p = .01$, $d = 0.729$), whereas older adults' recall scores did not differ between the two ($t = 0.579$, $p = .57$, $d = 0.154$; Figure 2). The mean number of neutral details that were correctly recalled did not differ between age groups ($t = 1.249$, $p = .22$, $d = 0.377$), whereas more humorous details were recalled by younger adults than by older ones ($t = 3.728$, $p < .001$, $d = 1.26$).

The mixed ANOVA conducted on the associative score revealed quite a similar pattern: no main effect of sequence type, $F(1, 37) = .62$, $p = .437$, $\eta^2 = .004$, a significant main effect of age group, $F(1, 37) = 14.69$, $p < .001$, $\eta^2 = .191$, with more associations being correctly recalled by younger adults ($M_{\text{Younger}} = 2.981$ vs. $M_{\text{Older}} = 1.95$), and an interaction between these two factors, $F(1, 37) = 7.72$, $p < .009$, $\eta^2 = .056$: younger adults recalled more humorous associations than neutral ones ($t = 2.49$, $p = .017$, $d = 0.684$), whereas older adults' recall did not differ between the two sequence types ($t = 1.427$, $p = .162$, $d = 0.382$; Table 2).

Cued Recall Phase

The mixed ANOVA showed that the detail cued recall score was significantly lower for older adults than for younger ones, $F(1, 37) = 23.6$, $p < .001$, $\eta^2 = .261$, and was higher for humorous sequences than for neutral ones, $F(1, 37) = 21.37$, $p < .001$, $\eta^2 = .102$ (Figure 3). More interestingly, it revealed a significant interaction between age group and sequence type, $F(1, 37) = 10.7$, $p = .002$, $\eta^2 = .051$: sequence type did not affect younger adults' recall ($t = 0.944$, $p = .351$, $d = 0.238$), but it did affect it in older adults, who recalled fewer humorous details than neutral ones ($t = 5.655$, $p < .001$, $d = 1.387$). Moreover, there was a difference between age groups for neutral ($t = 3.169$ $p = .003$, $d = 0.727$) and for humorous details ($t = 4.801$, $p < .001$, $d = 1.876$).[1] (Figure 3).

Figure 2
Mean Detail Free Recall Scores According to Sequence Type and Age Group in Study 1



Note. Error bars represent 95% confidence intervals. max = maximum.

Discussion

Overall, Study 1 replicated the results classically obtained in younger adults: participants judged humorous sequences as more funny than neutral ones and recalled more humorous sequences than neutral ones during the free recall task. We were therefore able to extend the positive effect of humor on memory that had previously been observed for cartoons (Takahashi & Inoue, 2009) and sentences (Schmidt, 1994) to sequences of photographs. This positive effect was not found in the cued recall task, probably due to high performance and low variability. In fact, the score of all younger participants was 8 or 9 (9 being the maximum score), for both the humorous and neutral sequences, with the exception of two participants who obtained a low score for the recall of the humorous sequences. In the light of these initial results, the Humour Associative Test therefore appears to be an appropriate paradigm for studying the effect of humor on memory and for testing how it changes in aging. As expected, older adults were sensitive to the funniness of the photographs, as they gave them higher funniness ratings than the neutral ones. Unexpectedly, however, older adults did not benefit from the effect of humor. Indeed, quite the opposite: They recalled just as many neutral sequences as humorous ones in the free recall task, and humor even had a detrimental effect in the cued recall task, with fewer humorous details recalled than neutral ones. At first glance, it would be easy to conclude that humor has a negative impact on memory in aging. However, before thinking about the reasons for this deleterious effect, we need to consider an alternative hypothesis, namely that the material used could be responsible for this effect. Humor is classically depicted as the feeling that emerges from the perception and awareness of an incongruity between two elements of the same situation (Martin, 2007). In our paradigm, humor was therefore triggered by the display of a detail that was unexpected, given the background featured in the first photograph. It was precisely because the detail was unexpected, and therefore inconsistent with the preceding scene, that the sequence was considered funny. We would therefore expect the background and detail of each humorous sequence to be only very weakly linked in semantic memory, with stronger links for neutral sequences. This means that in addition to the humorous dimension, the strength of the association between the elements to be memorized also has to be manipulated between conditions. Given the age-related deficit in associative memory (Naveh-Benjamin & Kilb, 2014), older participants may have had

[1] As the results of the Levene test indicated a violation of the homogeneity of variances between groups, and the Shapiro–Wilk tests suggested that the data deviated significantly from normality, we carried out nonparametric tests in addition to the initial mixed ANOVA. The results of the Kruskal–Wallis and Friedman tests revealed a pattern strictly identical to that of the ANOVA.

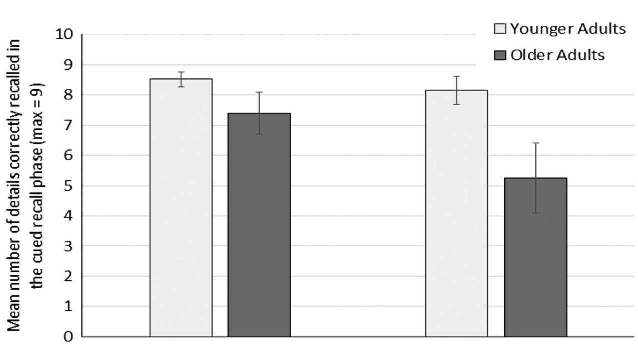
Table 2
Mean Associative Score (and Standard Deviation) According to Sequence Type and Age Group in Study 1

Sequence type	Younger adult	Older adult
Humorous	3.684 (1.336)	1.7 (1.418)
Neutral	2.789 (1.182)	2.2 (1.281)

more difficulty recalling the humorous sequences not because of the associated mirth but because of the weak relationships between the relevant elements.

To determine whether the results obtained in Study 1 stemmed from the humor per se or from the incongruity between the background and the added detail, we conducted a second study. A fresh sample of younger and older participants was recruited, and a new version of the Humour Associative Test was administered. The procedure was the same as in Study 1 but there were three experimental conditions: humorous sequences, characterized by high levels of humor and incongruity (similar to the humor condition in Study 1), neutral sequences, characterized by a low level of humor and a high level of incongruity (same levels of incongruity across humorous and neutral sequences, in order to isolate the effect of humor), and incongruous sequences, characterized by a low level of humor and higher level of incongruity (higher level of incongruity than in the two other conditions, in order to isolate the effect of incongruity). We tested two contrasting assumptions. First, if the age-related difficulty recalling humorous information in Study 1 was due to the incongruity between the background and the added detail, then older participants would perform similarly in the humorous and neutral conditions and less well than in the incongruous condition. By contrast, if the difficulty was due to the humor per se, then the neutral and incongruous sequences would be recalled better than the humorous ones. Whichever assumption was correct, we predicted that older adults would recall fewer incongruous sequences than neutral ones, in line with the associative deficit hypothesis (Naveh-Benjamin, 2000). We did not expect the younger adults' performance to differ between the neutral and incongruous sequences because of their efficient binding processes (Castel, 2005). Finally,

Figure 3
Mean Numbers of Details Correctly Recalled in the Cued Recall Phase in Study 1



Note. Error bars represent 95% confidence intervals. max = maximum.

we predicted that younger adults would exhibit a memory advantage for humorous sequences compared with the neutral and incongruous ones (e.g., Takahashi & Inoue, 2009).

Study 2

Method

Participants

Eighty-four adults participated in this study, conducted in the fall of 2021. The sample size was determined ahead of time, based on a power analysis using G*Power 3.1.9.4. The only previous study that had attempted to disentangle the effects of incongruity and humor on memory did not provide any effect sizes and only concerned young adults (Schmidt & Williams, 2001). The present sample size was therefore determined on the interaction results obtained in Study 1 for recall scores. Since the effect sizes varied, we adopted the most stringent criterion, focusing specifically on the smallest effect size, which corresponds to the detail free recall score ($\eta^2 = 0.41$). With $\alpha = .05$, power = .80, $\eta^2 = 0.41$, two groups, three measurements, and correlations between measures estimated to .3 (based on the correlations between the detail free recall scores for the two sequence types in Study 1), the total suggested sample size was 68. To account for potential errors during testing and the application of exclusion criteria, we aimed for an initial sample size slightly higher than this recommendation.

The method was almost identical to that used in Study 1. All the participants took part on a voluntary basis and gave their written informed consent. Exclusion criteria were based on the observation of an atypical cognitive or mood state, assessed by a neuropsychological test battery probing episodic memory (paired associative subtest of Wechsler Memory Scale; Wechsler, 2012), semantic memory (Isaacs Set Test, Binetruy et al., 2018; Ferreira et al., 2010), inhibition (Stroop interference test, Golden, 1978), flexibility (TMT, Binetruy et al., 2018; Ferreira et al., 2010), processing speed, anxiety, and depressive symptoms. Five participants were excluded because they had at least two atypical scores (<5th percentile or scores above cutoff). Four other participants were excluded from analyses because of computer issues during the Humour Associative Test.

The final sample consisted of 37 younger adults (M_{age} = 20.421 years, SD_{age} = 2.176; 14 men, 23 women) and 38 older adults (M_{age} = 71.351 years, SD_{age} = 6.25; 15 men, 23 women). Both groups had normal global cognitive functioning and did not differ in terms of either anxiety, depressive symptoms, or semantic memory scores (see Appendix C for details). By contrast, and as expected, the older adults performed more poorly on the tasks assessing processing speed, inhibition, and flexibility. The episodic memory performances of the two groups were within their respective age-based norms provided by the Wechsler Memory Scale battery, suggesting that our samples exhibited typical cognitive functioning[2].

[2] The two samples of older adults included in Studies 1 and 2 were comparable, as indicated by the absence of significant differences in independent *t* tests (or Welch tests) conducted on key characteristics typically considered in studies with older adults, including age, education level, global cognitive measures, and affective measures. The younger samples in Studies 1 and 2 were also similar in terms of global cognitive assessment and affective measures; however, younger participants in Study 1 were, on average, 2 years older than younger participants in Study 2 and therefore had two additional years of education.

Material and Procedure

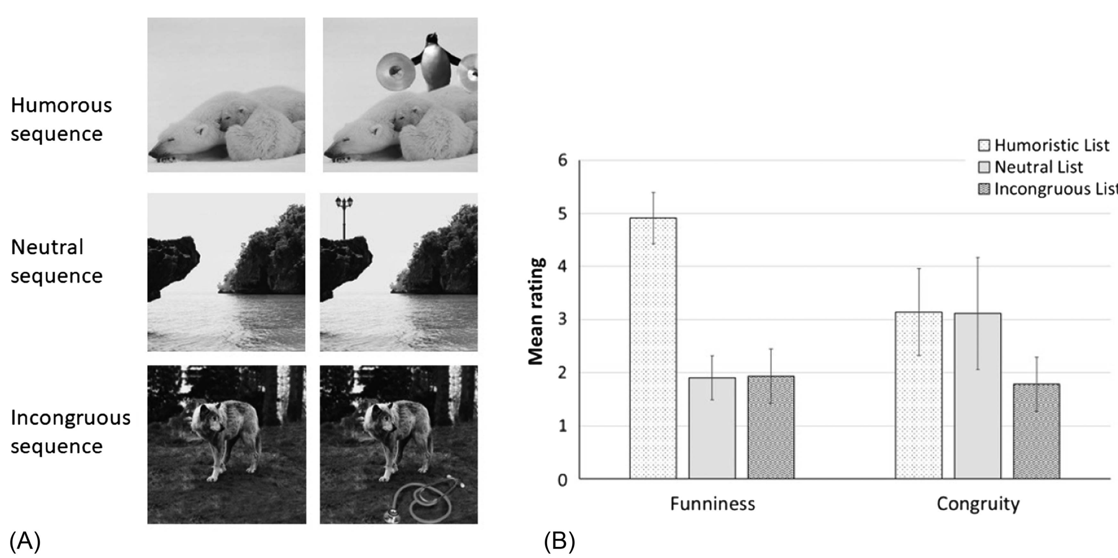
Humor Associative Test. Twenty-six two-photo sequences were used (24 sequences of black-and-white photographs for the test and two sequences of color photographs for training). As in Study 1, the first photograph depicted a neutral background, and the second one was nearly the same, except for the addition of one detail. In the eight humorous sequences, the added detail made the picture funny (and was, by essence, only weakly associated with the background). In the eight neutral sequences, the detail kept the picture neutral, and the link between the detail and the background was as weak as in the humorous sequences. For the eight incongruous sequences, the sequence remained neutral after the addition of the detail and the mismatch between the detail and the background (incongruity) was greater in this condition compared to the neutral sequences, which was even more incongruous considering the background. Social stimuli were present in three humorous, four neutral and six incongruous sequences. The distribution of social stimuli did not vary significantly according to conditions, $\chi^2(2) = 1{,}067$; $p = .58$. The creation of the material was based on the results of a pilot study conducted among 29 participants, where 40 sequences were successively displayed to participants, who had to rate their funniness on a Likert scale ranging from 1 (*not funny at all*) to 7 (*very funny*) and the incongruity between the background and the detail on a scale ranging from 1 (*absolutely do not fit together*) to 7 (*fit perfectly together*). Sequences were either taken directly from the material used by Schwartz et al. (2008) or specifically created for this study, by associating different details with the backgrounds used by Schwartz et al. (2008). Based on the collected data, we created three lists of eight sequences: a humorous list, a neutral list, and an incongruous list (see Appendix D for verbal description and image statistics of the photographs). An ANOVA revealed a significant effect of the list (i.e., humorous vs. neutral vs. incongruous) on funniness ratings, $F(2, 24) = 135.285$, $p < .001$, $\eta^2 = .919$, with the humorous list being funnier than the other two ($p < .001$), which did not differ (see Figure 4; Appendix E). The ANOVA conducted on the incongruity ratings showed that the incongruous list was rated as more incongruous than the other two lists, which did not differ from each other, $F(2, 24) = 9.477$, $p < .001$, $\eta^2 = .441$. Additional data collected from 23 additional older participants ($M_{\text{Age}} = 73.136$, $SD_{\text{Age}} = 5.07$) revealed a similar pattern of ratings: humorous and neutral sequences were judged similarly congruous, with both rated as more congruous than the incongruous sequences category.

Procedure. The procedure and scoring were the same as in Study 1. The only change concerned the number of sequences (24 instead of 18), owing to the use of three sequence types instead of two (see Figure 4). For each sequence type (humorous vs. neutral vs. incongruous, we calculated three scores: an associative score based on free recall answers, maximum = 8), a detail free recall score (maximum = 8) and a detail cued recall score (maximum = 8).

Transparency and Openness

We report how we determined our sample size, all data exclusions, all manipulations, and all measures in the study. All data have been made publicly available via the Open Science Framework at https://doi.org/10.17605/OSF.IO/RNXMW. Since the material used in this study is mostly sourced from the work of other researchers (Schwartz et al., 2008), we are not in a position to directly share this material. We invite interested parties to contact the original researchers directly for access to the material. Data were analyzed

Figure 4
Material Used in Study 2



Note. (A) Example of photographs used in encoding phase for each sequence type. (B) Mean funniness and congruity ratings (standard deviations) for each sequence type according to younger adults. Adapted from the material used in “Abnormal Activity in Hypothalamus and Amygdala During Humour Processing in Human Narcolepsy With Cataplexy,” by S. Schwartz, A. Ponz, R. Poryazova, E. Werth, P. Boesiger, R. Khatami, and C. L. Bassetti, 2008, *Brain: A Journal of Neurology*, *131*(2) (https://doi.org/10.1093/brain/awm292). Copyright 2008 by The Author(s). Adapted with permission.

using JASP 0.19.3. This study's design and its analysis were not preregistered.

Results

Statistical Analysis

Statistical analyses were the same as in Study 1, except that they were conducted on three sequence types (humorous vs. neutral vs. incongruous) instead of two. We looked for the effects of age group and sequence type on the funniness ratings and then on the three recall scores. Effect sizes were estimated using η^2 tests in ANOVA, and Cohen's d was employed when contrasts were conducted to further explore significant interactions.

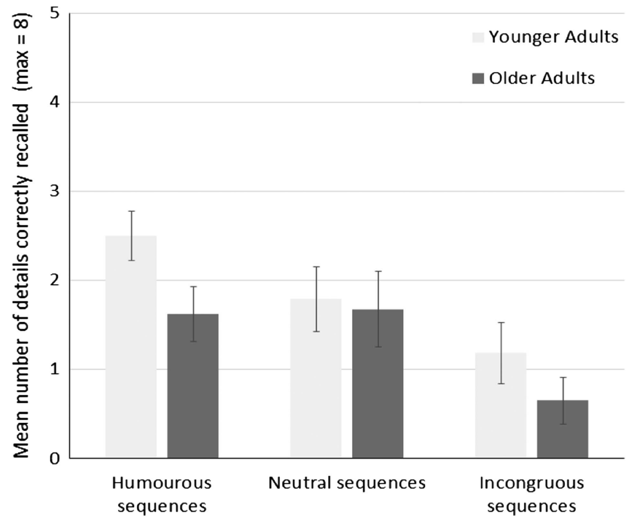
Encoding Phase

Results showed that older adults gave higher mean funniness ratings than young adults did, $F(1, 73) = 51.58$, $p < .001$, $\eta^2 = .156$, and that these ratings depended on sequence type, $F(2, 146) = 267.999$, $p < .001$, $\eta^2 = .47$: humorous sequences were rated as funnier than neutral or incongruous sequences (respectively $t = 17.549$, $p < .001$, $d = 2.39$; $t = 19.113$, $p < .001$, $d = 2.478$), which did not differ ($t = 0.929$, $p = .356$, $d = 0.088$). Moreover, there was a significant interaction between sequence type and age group, $F(2, 146) = 10.2$, $p < .001$, $\eta^2 = .018$: older adults generally rated the photographs as funnier than younger adults did, but the difference was smaller for humorous sequences ($t = 2.709$, $p < .01$; $d = 0.685$) than for neutral and incongruous sequences (respectively $t = 7.891$, $p < .001$, $d = 1.639$; $t = 7.082$, $p < .001$, $d = 1.630$; Table 3). Based on z-score calculations for the difference between d values, the results confirmed that the effect size was lower for the humorous sequences compared to both the neutral and incongruous sequences, which did not differ from each other ($Z_{\text{Humorous vs. Neutral}} = -2.67$, $Z_{\text{Humorous vs. Incongruous}} = -2.64$, $Z_{\text{Neutral vs. Incongruous}} = 0.024$).

Free Recall Phase

According to the mixed ANOVA conducted on the detail free recall score, younger adults recalled more details than older adults, $F(1, 73) = 10.193$, $p = .002$, $\eta^2 = .046$ (Figure 5). The effect of sequence type was also significant: humorous sequences were generally recalled better than neutral ones, which in turn were recalled better than incongruous ones, $F(2, 146) = 27.485$, $p < .001$ $\eta^2 = .165$; all $ps < .001$. As revealed by the almost significant interaction, this pattern nonetheless differed between the two age groups, $F(2, 146) = 2.902$, $p = .058$, $\eta^2 = .041$. Both groups showed a sequence-type effect (both $ps < .001$), but the conditions that differed varied. Pairwise comparisons showed that the younger adults recalled humorous sequences better than either neutral ($t = 2.943$, $p = .004$, $d = 0.975$) or incongruous ones ($t = 6.348$, $p < .001$, $d = 1.250$), which differed ($t = 2.753$, $p = .007$, $d = 0.575$). By contrast, older adults recalled fewer incongruous sequences than either humorous or neutral ones (respectively, $t = 4.632$, $p < .001$, $d = 0.924$; $t = 4.610$, $p < .001$, $d = 0.975$), which did not differ ($t = 0.221$, $p = .826$, $d = 0.051$).

Figure 5
Mean Detail Free Recall Scores According to Sequence Type and Age Group in Study 2



Note. Error bars represent 95% confidence intervals. max = maximum.

Concerning the associative score, results revealed quite a similar pattern, with significant main effects of age group, $F(1, 73) = 10.357$, $p = .002$, $\eta^2 = .052$, and sequence type, $F(2, 146) = 23.749$, $p < .001$, $\eta^2 = .136$, and an interaction between the two, $F(2, 146) = 4.697$, $p = .011$, $\eta^2 = .027$. Correct associations were more frequently recalled by younger adults than by older ones ($p = .002$), and humorous and neutral sequences were more frequently recalled than incongruous ones ($p < .001$), but the effect of sequence type differed between the two groups. As with the detail score, younger adults' associative score was higher for humorous sequences than for neutral ones ($t = 2.99$, $p = .004$, $d = 0.658$) and higher for neutral sequences than for incongruous ones ($t = 2.989$, $p = .004$, $d = 0.585$; see Table 4). In contrast, older adults showed no difference in recall between humorous and neutral sequences ($t = 1.01$, $p = .316$, $d = 0.225$) but recalled more associations for these two types of sequences than for incongruous ones (respectively $t = 3.354$, $p = .001$, $d = 0.676$; $t = 4.544$, $p < .001$, $d = 0.901$). An age-related difference in favor of younger adults was observed for humorous ($t = 4.29$, $p < .001$, $d = 0.991$) and incongruous sequences ($t = 2.246$, $p = .028$, $d = 0.424$), but there was no age difference for neutral sequences ($t = 0.405$, $p = .686$, $d = 0.108$).

Table 3
Mean Funniness Ratings (Standard Deviation) According to Sequence Type and Age Group in Study 2

Sequence type	Younger adult	Older adult
Humorous	2.895 (.483)	3.247 (.634)
Neutral	1.421 (.373)	2.264 (.539)
Incongruous	1.378 (.417)	2.216 (.595)

Cued Recall Phase

As illustrated in Figure 6, younger adults recalled more details in the cued recall phase than the older adults did, $F(1, 73) = 5.236$,

Table 4
Mean Associative Score (and Standard Deviation) According to Sequence Type and Age Group in Study 2

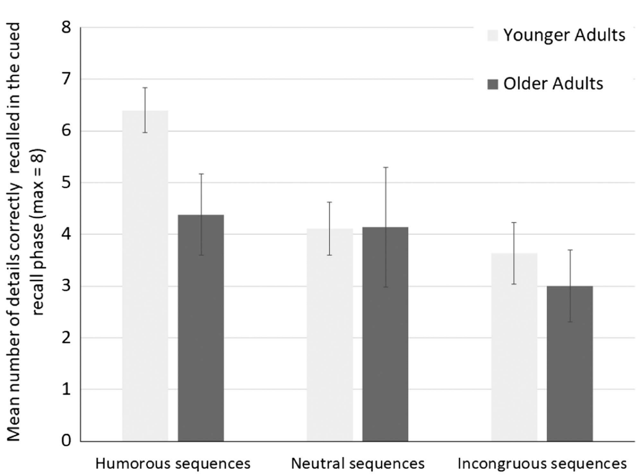
Sequence type	Younger adult	Older adult
Humorous	2.395 (1.001)	1.324 (1.156)
Neutral	1.684 (1.188)	1.568 (1.303)
Incongruous	1.053 (.957)	0.59 (.798)

$p < .025$, $\eta^2 = .04$. We also found that humorous details were better recalled than neutral ones, which in turn were recalled better than incongruous ones, $F(2, 146) = 52.026$, $p < .001$, $\eta^2 = .152$; all $ps < .001$. Finally, age group interacted with sequence type, $F(2, 146) = 13.013$, $p < .001$, $\eta^2 = .038$: older adults recalled fewer incongruous details than humorous or neutral ones (respectively $t = 4.687$, $p < .001$, $d = 0.71$; $t = 3.926$, $p < .001$, $d = 0.584$), which did not differ ($t = 0.836$, $p = .406$, $d = 0.125$). By contrast, younger adults recalled more humorous details than either neutral or incongruous ones (respectively, $t = 7.975$, $p < .001$, $d = 1.178$; $t = 9.522$, $p < .001$, $d = 1.422$), which did not differ ($t = 1.66$, $p = .101$, $d = 0.244$).

Discussion

The purpose of Study 2 was to better understand the mechanisms underlying the aging-related change in the effect of humor on memory observed in Study 1. To this end, we compared the recall of neutral photographic sequences with sequences that differed from neutral ones in either funniness or incongruity. Results revealed that when the level of incongruity did not differ between sequences older adults recalled as many neutral sequences as humorous ones, indicating no further negative humor effect on memory. This pattern of results clearly differed from that observed in Study 1, where a negative effect of humor was observed. This discrepancy and its theoretical implications are examined in the General Discussion section. Moreover, both groups showed an effect of incongruity on memory, with lower memory scores for incongruous sequences than for neutral ones. However, this decrease was more pronounced in older participants, whose performance was lower in the incongruous condition compared to younger adults, in contrast to the neutral condition. This pattern supports the notion of an associative memory deficit in aging (Naveh-Benjamin & Kilb, 2014). Finally, and in line with previous findings, younger adults recalled humorous sequences better than either neutral or incongruous ones (e.g., Schmidt, 2002), even in the cued recall task, confirming the beneficial effect of humor on memory in this population.

Figure 6
Mean Detail Cued Recall Score According to Sequence Type and Age Group in Study 2



Note. Error bars represent 95% confidence intervals. max = maximum.

General Discussion

A number of studies have demonstrated that younger adults show a memory bias in favor of humorous items over neutral ones (e.g., Carlson, 2011; Chambers & Payne, 2014, Schmidt, 1994, 2002; Schmidt & Williams, 2001; Takahashi & Inoue, 2009), but to date, no study has examined whether this advantage persists in aging. In two successive studies, we examined for the first time how humorous items are remembered by older adults and compared them with younger adults. We also wondered whether the use of humor can offset age-related memory decline. Overall, the results confirmed the beneficial effect of humor on memory in younger adults, but not in older ones. Contrary to our expectations, humor had either a detrimental effect on memory (Study 1) or no effect at all (Study 2). Several possible explanations for these original results are considered below.

First of all, it should be noted that the results for the younger group were in line with those that are classically observed, as they showed a beneficial effect of humor on memory in younger adults (e.g., Schmidt, 1994, 2002; Schmidt & Williams, 2001; Takahashi & Inoue, 2009). We highlighted this effect of humor on memory by administering a surprise memory test (incidental encoding) with free and cued recall to 57 participants, confirming Schmidt and Williams's (2001) results. Furthermore, our studies extended these results, as we showed that humor not only improves memory for single items but can also enhance associative memory performance. The effects of humor on memory have already been interpreted within the framework of the bizarreness effect (Schmidt & Williams, 2001) since both humorous and bizarre items are highly distinctive and share methodological and structural parallels (e.g., effects in within-list design only, recall of gists but not details…). In this context, three mechanisms have been proposed as potentially driving the enhanced processing of highly distinctive material, such as bizarre or humorous items: expectation violation, selective rehearsal, and spontaneous elaboration (Waddill & McDaniel, 1998). The expectation violation hypothesis suggests that participants are surprised when encountering humorous stimuli within nonhumorous content, enhancing memory retention. However, this hypothesis has been largely dismissed, as the memory effect of humor persists even when participants are informed in advance that humorous material will be presented. Second, humorous material might be better remembered due to its increased repetition compared to nonhumorous material. However, this hypothesis appears highly unlikely under the conditions of incidental encoding, as in our studies. Finally, two forms of spontaneous elaboration have been identified: a context-dependent elaboration (Schmidt & Williams, 2001) and an interpretative elaboration. In the context-dependent elaboration hypothesis, humorous items receive deeper processing because they are atypical within the experimental set, making the humor effect distinctive and contextually specific. The second type, interpretative elaboration, is of particular interest here. It involves the cognitive processes required to resolve the incongruities inherent in humorous material, independent of contextual cues. As a reminder, in the incongruity-resolution theory of humor comprehension (Suls, 1972), humor arises through a two-step process: one/detecting an incongruity between information and expectations and two/resolving this incongruity by identifying a rule or frame that reconciles the incoherent information with the initial context in a way that is both logical and unexpectedly amusing. In our study, taken in isolation, neither element (nor the backgrounds nor the details) were inherently funny; it is only when the background was integrated with the added detail that the association gains a humorous dimension. In sum, the combined results of Studies 1 and 2 suggest that the positive effect of humor in younger adults may stem not only from the process of incongruity detection (since incongruity was present in all sequences in Study 2) but also from the resolution of this incongruity. For sequences lacking a resolution (whether neutral or specifically incongruous), participants indeed demonstrated lower memory performance. In addition to incongruity resolution, it is plausible that further, emotionally driven processes may contribute. This idea was previously proposed and tested by Carlson (2011), who compared memory recall for two types of images requiring incongruity resolution: some humorous and others described as inspiring. The results indicated better recall for humorous images, especially when they were subjectively rated as amusing, supporting the argument for a role of emotional factors as well.

The emotional component of humor is yet one of the distinctive aspects that sets it apart from mere bizarreness. Beyond the cognitive mechanisms, the emotional aspect of humor—highlighted in neuroscience research (for a review, see Rodden, 2018)—may help explain humor's memory-enhancing effects. As humorous items elicit a pleasant emotional response, such as mirth and/or physiological arousal, at least to some degree (Martin, 2007), they may be considered as a specific subset of positive emotional stimuli. In this case, it suggests that humorous items might be subject to the same influences and processing specificities as other emotionally positive items, which are extensively reported to be better memorized than neutral content (Bradley et al., 1992; Hamann, 2001; Kensinger et al., 2002). The EEM appears to be driven by increased attentional engagement for emotional elements (Christianson et al., 1991; Talmi et al., 2007), which promotes prioritization or even automatization of their processing (Dolan & Vuilleumier, 2003). Later, more controlled elaborative processes would lead to favor the storage of central elements of an event over peripheral details. Supporting this idea with humorous material, Schmidt and Williams (2001) found that while the gist of humorous cartoons was better recalled than nonhumorous or "weird" versions of the same cartoons, the humorous effect did not extend to specific details, such as cartoon wording. Finally, this pattern aligns with broader research on emotional memory, which suggests that emotional content, because of its rarity, stands out as distinctive. The emotional enhancement of memory would therefore result from the item distinctiveness (McCloskey et al., 1988; Schmidt, 2002). The fact that the effect of humor on memory is only observed in mixed lists reinforces this theory. These distinctive/humorous items would therefore receive increased processing relative to common items.

Additionally, the positive effect of humor on memory may be traced to brain activation linked to its emotional component. Humor processing engages the reward network within the limbic system (Mobbs et al., 2003) and activates the amygdala, a pivotal brain structure for emotional processing. For example, Nakamura et al. (2018) demonstrated that the left amygdala is involved in resolving the incongruity in humorous sentences, an activation associated with both the emergence of a positive emotion upon understanding the humorous nature of sentences and the detection of an event relevant to the organism (Sander et al., 2003). Notably, the fact that the amygdala is involved in the encoding and retrieval of emotional information by modulating hippocampal activity (Phelps, 2004) provides a potential neurophysiological basis for humor's positive effect on memory.

Thus, although these hypotheses are often considered exclusively, we believe that both incongruity resolution and the emotional response to humor contribute to its positive effect on memory.

As the results for younger adults were consistent with our assumptions and with previous results, the humor associative task employed in our two studies seems to offer a valid means of testing the effect of humor on memory and its variability in aging. We expected to observe a positive effect of humor on memory in older adults as well as younger ones, so it was surprising not to observe it. In fact, this effect was even negative in Study 1 as the older participants recalled more neutral items than humorous ones. When the level of incongruity did not differ between the sequences, this negative effect disappeared, but there was still no effect of humor. To our knowledge, only one prior study has explored a rather similar area in aging (Bains et al., 2014). Although the methodology cannot be directly compared with that of our studies and did not evaluate the cognitive component of humor (as the memory test did not include humorous material), Bains et al.'s finding showed that viewing humorous videos was associated with improved memory performance in older adults, underlying the preservation of humor's affective component (mood change). So, how can we explain the absence of humor effect on memory in normal aging? The selection of our humorous material does not appear to be a cause as we carefully avoided types of humor generally disliked by older people, such as aggressive humor or content related to aging (Greengross, 2013). There is, therefore, no reason to believe that older adults would not appreciate the humorous sequences. Besides, although the photographs were primarily validated only with younger adults (Schwartz et al., 2008), the results suggest that older adults were able to distinguish neutral from humorous sequences. In fact, they assigned higher funniness ratings to the intended humorous photographs than to the neutral ones, attesting for their ability to detect the humorous aspect of the material. Moreover, older participants rated the humorous photographs as even funnier than younger participants did. This suggests that older adults are not only able to perceive the humor dimension but also appreciate it and experience an even stronger positive emotional response than younger people.

In the literature, it has already been emphasized that older people report more positive experiences and emotions than younger people (Burr et al., 2021; Mak & Schneider, 2022). This positivity effect (Mather et al., 2004; Mikels et al., 2005) can be explained by socioemotional selectivity theory (Charles & Carstensen, 2007).

According to this theory, given their more limited time perspective, older adults tend to prioritize present-oriented goals such as positive emotional experiences over future-oriented goals such as the acquisition of new knowledge or expanding horizons (Reed & Carstensen, 2012). Older people are thus more inclined to focus on emotionally meaningful goals. Consequently, they become more selective about how and with whom they spend their time, which help explains the smaller size of their social network. This indicated a preference for quality over quantity in their social relationships. Additionally, older adults are more likely to shift their attention and memory toward positive aspects of life rather than negative ones. Rather than merely avoiding negative emotions, older people actively cultivate an environment conducive to their well-being (Carstensen et al., 2024). So, to observe a positive effect, the emotional stimuli chosen must have emotional and personal relevance in the lives of the older adults. In this sense, it is possible that our humorous sequences did not have enough emotional significance for older adults.

Besides, we assume that our results may be mainly explained by the presence of an associative memory deficit in aging, often described in the aging literature (Naveh-Benjamin & Kilb, 2014). According to this hypothesis, older participants experience more difficulty in forming and maintaining associations between distinct elements—such as content and context—which could account for their reduced recall of information. Even if our task, by its very nature, requires elements to be linked together, whatever the condition, this link was more difficult to achieve in the incongruous items condition (weaker link between detail and background and impossibility to resolve incongruity, particularly in older subjects). Furthermore, the humorous nature of the items did not help older adults to create this link, unlike younger subjects. As we saw previously, processing humor involves resolving the incongruity in order to understand the joke. This process is akin to problem solving and is therefore cognitively costly. In their study, Shammi and Stuss (2003) have clearly shown that performances on humor tests were correlated with scores on working memory, abstract thinking, and visual perception and attention. Based on these findings, we propose that the cognitive demands inherent in processing humorous sequences may hinder the formation of strong memory associations in older adults with limited cognitive resources. To explore this hypothesis, we conducted preliminary analyses using a composite score reflecting executive functions and examined its correlation with memory performance (see Appendix F). The results revealed overall positive correlations, with stronger associations observed in the humorous condition compared to others. These findings provide preliminary evidence supporting our hypothesis that the cognitive demands of humor processing may exacerbate memory difficulties in older adults. Future research employing more refined methodologies will allow for a deeper investigation of this proposition.

This hypothesis could be linked to previous research that showed that older adults have a deficit in distinctive processing (e.g., Cimbalo & Brink, 1982). Indeed, there may be normative declines in normal aging that may lead to a reduction in cognitive resources. Moreover, it has been shown that the bizarreness effect (better recall of weird items than common items) is also attenuated in normal aging (Black et al., 2012; Nicolas & Worthen, 2009). Yet, Worthen and Loveland (2003) have shown that the bizarreness effect results in poor item integration during encoding.

Constraints on Generality

While our results are indeed novel and of high theoretical interest, it is essential to acknowledge and explore certain limitations within our study, particularly concerning the population and method utilized.

Regarding our population demographics, in both studies, we tried to recruit participants from a wide range of educational backgrounds (from no high-school diploma to PhD) to take account of the variability of the population. Even our groups of young adults comprised individuals who were not enrolled as students and who had not pursued their studies beyond the bachelor's degree. By contrast, we did not take a specific attention to the ethnic diversity of our sample. Moreover, as these two studies were the first to investigate how humor affects memory in aging, we recruited participants spanning a wide range of older ages (60–90 years) to get an initial understanding of the influence of humor on memory during the aging process, in a broad sense. However, it might have been more appropriate to form several groups of older adults, as cognitive deficits could change significantly between the ages of 60 and 90 years. Comparing more homogeneous and narrower age groups would have enabled a more precise examination of the evolution of the effect of humor on memory over the course of adult life. Finally, various individual factors, such as sense of humor, personality, gender, or affective state, can affect the way in which people perceive or understand humorous materials (Chang et al., 2018; Greengross, 2020; Silvia et al., 2021) and were not controlled for in these studies. It would therefore be relevant to control for them or even to test their potential moderating role in future studies.

As far as the method is concerned, we opted for the incidental encoding of the items, which in our view corresponded more closely to ecological situations and has been demonstrated to effectively reveal the impact of humor on memory (e.g., Takahashi & Inoue, 2009). However, since intentional encoding may be more likely to reveal the influence of humor on memory (e.g., Schmidt, 1994), we cannot dismiss the possibility that older participants might exhibit a different pattern of humor's effect under such conditions. In these situations, older participants may employ alternative encoding strategies that could help mitigate potential memory deficits. In fact, recent studies suggest that some of the associative memory specificities that appear in older people may be particularly sensitive to instructions and how it directs their attention during encoding (Campbell & Hasher, 2018; Swirsky & Spaniol, 2020). On top of that, it is crucial to note that our procedure and material were tailored specifically to investigate associative memory. This aspect could have had a significant influence on our findings, especially in the context of aging. However, it is important to recognize that humor is not a singular dimension; instead, it is a multifaceted construct with various types distinguished (e.g., Martin et al., 2003). Thus, the current lack of effect of humor on memory in aging may be specifically due to the form of humor that entails a mismatch between participants' expectations and subsequent events. Different processes, and potentially distinct age effects, could be elucidated using tasks involving absurdist humor or repetition humor, for example. In the same vein, we investigated the humor effect solely with visual material (i.e., photographs), and it would be interesting to find out whether results vary according to the medium (e.g., verbal jokes), especially since the associative memory deficit in aging differ between pictures and words (Endemann & Kamp, 2022).

Finally, like many others, we carried out a cross-sectional study. However, we cannot ignore a possible effect of cohort on age-related humor appreciation. Humor is influenced by context (e.g., unique life experiences and social and cultural norms; Greengross, 2013). Thus, humor can change across generational cohorts, and what makes people laugh may vary from one generation to the next. It would therefore be interesting to carry out a precise assessment of the types of humor appreciated by the different groups of participants.

The interplay of these many factors testifies to the complex nature of humor processing and suggests that aiming to capture the effects of multiple factors involved in humor comprehension is a useful approach to disentangling processing differences in joke comprehension.

To conclude, the present study was the first to assess the recall of humorous items in normal aging. We showed that, unlike young adults, older adults did not benefit from the effect of humor on memory. This is an interesting result, but it needs to be replicated using other types of material (e.g., verbal material), in order to rule out a possible effect linked not to humor but to our material and instructions (strongly eliciting associative memory). We believe that the lack of effect may have occurred because participants' cognitive load was too high to process humorous material compared with neutral material. This hypothesis should also be tested by varying the cognitive load of the humorous material used.

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(*Appendices follow*)

Appendix A

General Demographic Data and Neuropsychological Characteristics of Two Age Groups in Study 1

Demographic and neuropsychological characteristic	Younger adult (n = 19) M (SD)	Older adult (n = 20) M (SD)	Age group effect p value
Age (in years)	22.98 (2.3)	75.5 (9)	<.001[c]
Sex ratio (male:female)	4:16	10:9	.034 [d]
Education level (in years)	21.37 (2.16)	18.65 (6.2)	.012[a]
MMSE score (/30)	28.89 (1.3)	28.15 (1.6)	.134[a]
PHQ-9 score	7.95 (4.45)	6.2 (4.7)	.142[a]
STAI-anxiety state score	33 (8.429)	42.474 (11.355)	.005[a]
FCSRT total free recall	47.68 (1.16)	44.35 (3.73)	<.001[a]
DO 30 naming test	28.68 (1.11)	29.35 (0.99)	.049[a]
Stroop interference test	15.15 (7.67)	1.8 (6.49)	<.001[b]
TMT Part A (in seconds)	19.36 (4.23)	52.2 (23.87)	<.001[a]
TMT Part B (in seconds)	58.63 (20.08)	139.4 (83.64)	<.001[a]
TMT B-A (in seconds)	39.26 (18.46)	87.2 (64.95)	.005[a]

Note. MMSE = Mini-Mental State Examination; PHQ-9 = Patient Health Questionnaire–9; STAI = State-Trait Anxiety Inventory; FCSRT = Free and Cued Recall Selective Reminding Test; DO 30 = 30-item oral picture naming task; TMT = Trail Making Test.
Comparisons were assessed with [a] Mann–Whitney U test. [b] t test. [c] Welch's test or [d] Chi-squared test.

Appendix B

Verbal Description and Image Statistics of Photographs Used in Study 1

Photo	Verbal description	M	SD	ID	Kurtosis
H1.1	Polar bear and her cub are asleep	199.743	34.345	59328604	4.967
H1.2	A penguin is about to play cymbals above them	189.037	44.106	56148611	3.184
H2.1	A dolphin jumps out of the water	94.507	38.128	28070894	2.186
H2.2	A cow does the same next to it	101.067	49.681	30019409	−0.074
H3.1	Men with their backs to the wall are being searched by a policeman	137.038	77.489	40703672	−1.196
H3.2	A dog is in the same position, standing on its hind legs	129.606	78.050	38496196	−1.312
H4.1	A bathtub	173.179	28.524	51438617	3.865
H4.2	A woman gets out of the bathtub wearing a scuba diving mask	170.437	34.844	50624049	4.018
H5.1	Sheep graze in a meadow	102.948	44.865	30578021	−0.723
H5.2	A wolf jumps over one of them	101.189	45.931	30055731	−0.806
H6.1	An earth turtle	156.508	42.266	46486853	2.899
H6.2	A fired missile is fixed to the turtle's shell	148.254	48.718	44035055	1.124
H7.1	A man in profile wipes his hands with the towel from a hand towel dispenser	148.116	54.763	43994056	1.191
H7.2	A second man in profile wipes his hands on the first man's jacket	124.756	70.494	37055556	−0.894
H8.1	A cyclist carries a high pile of newspapers on the luggage rack	118.051	73.973	35064013	−1.335
H8.2	A man sits at the top of a higher pile and reads a newspaper	119.820	72.836	35589570	−1.284
H9.1	A mouse looks at a piece of cheese hanging from a mousetrap	189.541	42.938	56298559	4.454
H9.2	The mouse wear an American football helmet	192.512	40.440	57180751	6.599
N1.1	The legs of a person holding a dog on a lead to their left.	125.280	54.344	37211439	−0.858
N1.2	A dog on a lead to their right	126.458	58.383	37561117	−0.964
N2.1	A cliff above a river with a hill in the background distance	163.588	85.556	48589759	−1.189
N2.2	A man is sitting at the edge, gazing into the distance	160.791	86.103	47758944	−1.276
N3.1	A woman from the 1960s fixing her hair, with a table to her left	155.793	71.312	46274467	−1.362
N3.2	A poodle on the table looks at her	150.848	71.211	44805716	−1.395
N4.1	An elderly woman standing in front of her house with the door open doorway	50.781	63.941	15083213	1.241
N4.2	Another old woman stands in the doorway	67.641	69.691	20091210	−0.180
N5.1	A rural landscape with a path in the foreground	116.947	67.309	34736181	−0.843
N5.2	A goat is on the road	119.386	69.978	35460564	−1.050
N6.1	A partially opened oyster	61.623	37.410	18303448	0.685
N6.2	A pearl is at the center of the oyster	62.920	39.622	18688665	1.143
N7.1	A frontal view of a monkey's head	35.817	37.768	10638604	2.566
N7.2	A second monkey stands to his left	44.882	38.419	13331112	1.946
N8.1	A man jogging by the sea	120.983	50.389	35934983	−0.663
N8.2	Another man runs alongside him	116.603	53.303	34633909	−0.830
N9.1	Two decorative eggs and a hamster on a tray	134.407	44.015	39922260	0.683
N9.2	A third egg is on the table	127.955	47.859	38005953	−0.116

Note. H = Humorous; N = Neutral; M = Average Pixel Intensity Value; SD = Standard Deviation, that is, measure of the dispersion of the pixel intensity values around the mean; ID = Integrated Density, that is, the total of the pixel intensity values; Kurtosis = Shape of pixel intensity distributions.

(*Appendices continue*)

Appendix C

General Demographic Data and Neuropsychological Characteristics of Two Age Groups in Study 2

Demographic and neuropsychological characteristic	Younger adult (n = 37) *M* (*SD*)	Older adult (n = 38) *M* (*SD*)	Age group effect *p* value
Age (in years)	20.421 (2.176)	71.351 (6.25)	<.001
Sex ratio (male:female)	15:23	14:23	.884
Education level (in years)	18.394 (1.498)	17.55 (2.946)	.082
MMSE score (/30)	28.737 (1.079)	28.189 (1.561)	.081
PHQ-9 score	5.921 (3.49)	5.162 (3.354)	.34
STAI-state score	28.737 (6.332)	27.27 (7.567))	.169
Paired associative subtest (standard score)	9.842 (1.994)	10.270 (3.142)	.464
Isaacs Set Test	40.632 (10.708)	38.973 (13.194)	.155
Stroop interference test	8.431 (11.786)	-7.353 (7.613)	<.001
TMT Part A (in seconds)	25 (9.676)	40.806 (14.985)	<.001
TMT Part B (in seconds)	59.184 (15.589)	102.543 (35.347)	<.001
TMT B-A (in seconds)	34.514 (13.858)	60.333 (35.108)	<.001

Note. Comparisons were assessed with Mann–Whitney *U* tests, as the data deviated significantly from a normal distribution (Shapiro–Wilk), or with a chi squared test (for the sex ratio variable). MMSE = Mini-Mental State Examination; PHQ-9 = Patient Health Questionnaire–9; STAI = State-Trait Anxiety Inventory; TMT = Trail Making Test.

Appendix D

Verbal Description and Image Statistics of Photographs Used in Study 2

Photo	Verbal description	*M*	*SD*	ID	Kurtosis
H1.1	Sheep graze in a meadow	102.948	44.865	30578021	−0.723
H1.2	A wolf jumps over one of them	101.189	45.931	30055731	−0.806
H2.1	Volleyball players jump, arms outstretched, behind a volleyball net to block the ball.	93.736	40.427	24189877	1.526
H2.2	A cat is next to them, in the same position, ready to intercept the ball	95.385	43.566	24615350	1.133
H3.1	A very little dog runs up a steep mountain slope	86.696	48.573	22373034	−0.219
H3.2	A muscular man holds the dog's lead, seemingly lifted off the ground by the dog's energetic run.	92.421	49.468	23850546	−0.351
H4.1	Polar bear and her cub are asleep	199.733	34.345	51543881	4.967
H4.2	A penguin is about to play cymbals above them	189.025	44.106	48780535	3.186
H5.1	Men with their backs to the wall are being searched by a policeman	137.038	77.489	40703672	−1.196
H5.2	A dog is in the same position, standing on its hind legs	129.590	78.050	38491538	−1.314
H6.1	A dolphin jumps out of the water	94.496	38.128	24385982	2.185
H6.2	A cow does the same next to it	101.057	49.681	26079212	−0.074
H7.1	An earth turtle	156.923	42.266	46609954	3.069
H7.2	A fired missile is fixed to the turtle's shell	148.254	48.718	44035053	1.124
H8.1	A mouse looks at a piece of cheese hanging from a mousetrap	189.541	42.938	56298559	4.454
H8.2	The mouse wear an American football helmet	192.512	40.440	57180751	6.599
N1.1	A vintage car parked along a sidewalk, all in a 60s atmosphere	87.017	74.801	22455909	−1.031
N1.2	A bale of baited straw is laid on the sidewalk	98.557	70.814	25433920	−1.063
N2.1	A golfer on a green, club in hand, getting ready to putt	119.143	50.128	30746626	−0.673
N2.2	A handbag is lying next to her	118.222	50.227	30508806	−0.704
N3.1	Two woman standing in front of a house with the door open doorway	67.636	69.697	17454330	−0.182
N3.2	One of them is holding a racket	67.034	68.797	17298944	−0.076
N4.1	Three people looking at a document on a desk	150.646	89.800	38876437	−1.666
N4.2	A headset is placed on the desk	148.949	88.980	38438308	−1.695
N5.1	A rural landscape with a path in the foreground	116.936	67.104	30176883	−0.831
N5.2	A pair of boots is on the road	114.515	68.382	29552208	−0.845
N6.1	Two children fishing in a lake, a table with various items is at their feet	166.576	68.109	42987242	−0.703
N6.2	A pineapple lies on the ground	165.833	68.785	42795538	−0.736
N7.1	A cliff above a river with a hill in the background distance	163.576	85.538	42212949	−1.187
N7.2	A lamp-glass is situated at the edge	162.495	85.669	41934017	−1.220
N8.1	A bicycle is leaning against a bridge barrier	101.265	43.305	26132877	0.003
N8.2	A sandwich is placed on his luggage rack	101.192	43.706	26114033	−0.004
I1.1	A sea turtle swims in the water	68.364	26.883	17642165	6.893
I1.2	An old open article lies behind her in the water	83.878	50.696	21645959	1.832
I2.1	A wolf in the middle of a clearing	67.674	45.964	17464281	2.444

(*Appendices continue*)

Appendix D (*continued*)

Photo	Verbal description	*M*	*SD*	ID	Kurtosis
I2.2	A large stethoscope lies at his feet	69.554	48.298	17949375	1.708
I3.1	A bullfighter in a bullring poses after a pass	98.263	40.112	25358270	−0.457
I3.2	An imposing pair of barbells lies on the floor	93.877	40.569	24226246	−0.169
I4.1	A sleeping hunter sits at the foot of a tree on the edge of the forest	73.658	49.133	19008429	−0.582
I4.2	A large Greek column is in the foreground in the grass	79.941	50.389	20630001	−0.955
I5.1	A smartly dressed man rides a bicycle	134.487	67.390	34706266	−1.554
I5.2	A 50s armchair with a high seat and compass base is on the road	133.402	63.966	34426281	−1.414
I6.1	Four people art talking around a desk, business meeting atmosphere	106.208	67.183	27408516	−1.474
I6.2	One of them is holding an adjusting wrench	105.534	67.131	27234459	−1.474
I7.1	Two young girls stand at the edge of a swimming pool	100.155	68.938	25846322	−1.285
I7.2	A wooden console with three drawers is positioned beside them	100.740	67.636	25997476	−1.228
I8.1	The head of a camel looking to the left	115.496	35.362	29805289	−0.342
I8.2	A young businessman in a three-piece suit and tie is on the phone in the foreground	113.792	43.227	29365652	0.402

Note. H = Humorous; N = Neutral; I = Incongruous; *M* = Average Pixel Intensity Value; *SD* = Standard Deviation, that is, measure of the dispersion of the pixel intensity values around the mean; ID = Integrated Density, that is, the total of the pixel intensity values; Kurtosis = Shape of pixel intensity distributions.

Appendix E

Mean Funniness and Congruity Ratings for the Three Types of Sequences Employed in Study 2

Rating of material according age group	Humorous sequence	Neutral sequence	Incongruous sequence
Younger adults			
Funniness	4.911 (.483)	1.9 (.414)	1.932 (.515)
Congruity	3.319 (.813)	3.114 (1.057)	1.779 (.51)
Older adults			
Funniness	5.098 (.718)	3.739 (.529)	2.984 (.554)
Congruity	4.119 (.718)	3.516 (.968)	2.84 (.602)

Appendix F

Exploratory Analyses: Correlations Between Executive Function and the Memory Scores

To test the hypothesis that the cognitive costs associated with processing humor could explain the lack of a beneficial effect of humor on memory for older participants, we performed preliminary analyses using a composite score derived from the two most relevant tests in our cognitive assessment battery, specifically those targeting executive functions. This composite score was calculated as the mean of the *z*-scores from the Stroop test and the reversed *z*-score from the Trail Making Test. Correlations between this composite executive score and the memory scores ranged from .096 to .47, with all three correlations in the humorous condition reaching significance, whereas none of the correlations in the neutral or incongruous conditions were significant, whatever the score (see Table F1 below).

Table F1

Pearson's Correlations Between the Composite Executive Score and Memory Scores by Sequence Type (Humorous, Neutral, Incongruous)

Sequence type	Detail free recall score	Associative free recall score	Detail cued recall score
Humorous	.317***	.406**	.470***
Neutral	.182	.209	.095
Incongruous	.173	.233	.162

** $p < .01$. *** $p < .001$.

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