

Cognitive Psychology

# The Relationship Between Subjective Memory Experience and Objective Memory Performance Remains Stable Across the Lifespan

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The way humans remember events changes across the lifespan. Older adults often rate the vividness of their memories as being greater or equal to younger adults, despite poorer performance on episodic memory tasks. This study explored how the content (place, person and object) and specificity (conceptual gist versus perceptual detail) of event memories relate to the subjective experience of memory vividness and memory confidence, and how this relationship is affected by healthy ageing. 100 healthy older adults and 100 young adults were tested online, using an adapted version of a paradigm developed by Cooper and Ritchey (2022). At encoding, participants generated a distinctive story to associate together (1) a theme word, and images of (2) a famous person, (3) a place, and (4) an object, to create unique events. At test, participants identified the event components using word labels (indexing conceptual gist), and the studied images (indexing perceptual details). Replicating Cooper and Ritchey (2022), we found that young adults' memory vividness ratings were related to their memory for the conceptual gist of the events, with no modulation by the type of the content recalled. Strikingly, older adults showed the same relationship between vividness measures and objective performance as the young adults. Contrary to some previous studies, we found that older adults obtained lower scores for gist-based memory, and their vividness ratings were correspondingly lower than the younger adults. Across both age groups, vividness and confidence ratings followed a similar pattern, showing a stronger relationship with conceptual gist. Our results suggest that throughout the lifespan, the amount of conceptual information retrieved about an event relates to the ability to reexperience it vividly, and to have confidence in one's memory.

Recollecting the past involves both retrieving information and reimagining experiences in our mind's eye. Furthermore, our recollective experience is accompanied by a sense of confidence about the accuracy of our memory. Neuropsychological and neuroimaging studies suggest that subjective and objective attributes of episodic memory rely on different neural substrates (Richter et al., 2016; Simons et al., 2010; Yazar et al., 2014). This separation is further emphasized by the recent findings in the ageing literature. While performance on episodic memory tests generally declines with age, older adults' subjective sense of memory vividness is often maintained or even increased in comparison to young adults (Folville, Bahri, et al., 2020; Folville et al., 2022; Korkki et al., 2020; St-Laurent et al., 2014). Nevertheless, the relationship between successful memory performance and subjective memory experience remains poorly understood (Simons et al., 2022), especially the

question of whether this relationship changes with age. The purpose of this study is to investigate whether the correspondence between objective and subjective memory changes across the lifespan.

Remembering is not an all-or-none phenomenon; events are recalled with varying amounts of detail and accuracy. Successful memory performance is therefore often considered at different levels of specificity (e.g. Reyna & Brainerd, 1995). In the current study, we investigate memory across two broad levels; "gist" and "detail". Gist-level memories refer to conceptual information about the elements present, such as being able to name people and objects present during an event. By contrast, detail-level memories refer to specific perceptual information, such as the clothes a person was wearing or the size and colour of objects. Ageing has been associated with a decline in detail memory performance, but relatively preserved gist memory (Abadie et al.,

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2021; Greene & Naveh-Benjamin, 2020; Grilli & Sheldon, 2022). Furthermore, age was linked to decreased memory precision (a continuous measure of memory accuracy that is related more to “detail”), but had less effect on retrieval success (a thresholded measure of memory retrieval that is related more to “gist”) (Korkki et al., 2020; Nilakantan et al., 2018). The age-related decline in memory for item-specific information (Koutstaal & Schacter, 1997) and increased reliance on gist-level memories in older adults have been associated with increased likelihood of false memories (Dennis et al., 2007).

Older adults are not only more likely to have false memories, but also show increased confidence in those false memories (Dennis et al., 2007; Shing et al., 2009). This tendency mirrors the increase in subjective vividness observed in studies measuring episodic details, where older adults rate the vividness of their memories higher than young adults, despite recalling fewer episodic details (Folville, Bahri, et al., 2020). McDonough and colleagues (2014) addressed this finding by showing that recollection-linked fMRI activity in visual processing regions was reduced in older adults, despite the older adults rating their memories as being as detailed as younger adults. The authors argued that older adults retrieve less information than young adults, but they recalibrate their subjective assessment of memory to this reduced amount of available episodic memory details. However, previous studies have not tested what type of information older adults rely on when making a subjective vividness memory judgement, and whether it is more conceptual or perceptually detailed in nature.

Cooper and Ritchey (2022) showed that young adults’ subjective vividness ratings are more strongly related to their conceptual gist memory of events than to the ability to remember perceptual details. Previous research has shown that older adults appear to rely on gist-level memory to a greater extent than young adults (see Grilli & Sheldon, 2022), and that they rate the vividness of their memories as equally high or even higher than young adults (Folville, Bahri, et al., 2020; Johnson et al., 2015). An interesting unexplored hypothesis is whether the inflated vividness ratings often observed in older adults reflect the reliance on gist memory in this age group. One aim of this study is to test whether older adults’ subjective memory ratings are predicted to a greater extent by conceptual gist than by perceptual detail memory, and whether this effect is stronger than in young adults.

Objective memory performance can be evaluated not only in terms of specificity, but also according to its content, such as an event’s location, the people present and their actions. Here, we are interested in whether the retrieval of some elements of an event is particularly linked to subjective measures of memory. One possibility is that all elements of an event are equally associated with subjective measures of memory, since episodic memory is predominantly holistic and retrieval of the individual elements is likely to co-occur (Horner & Burgess, 2013). However, some research has placed particular importance on the spatial context, showing a primacy of spatial information when creating a mental image (Horner et al., 2016; Robin et al.,

2016). Consistent with this, Cooper and Ritchey (2022) found that successful retrieval of place information provided a small additive boost to memory vividness in young adults. Nevertheless, others have reported that the self-perceived quality of autobiographical memories relates more to object imagery ability over spatial navigational abilities (Fan et al., 2021). Whether or not the retrieval of different elements of an event influences the self-perceived quality of episodic memory in an older population is not known.

The present study uses a newly developed paradigm to probe memory for multi-element events at the level of both conceptual gist as well as low-level perceptual information (Cooper & Ritchey, 2022). The paradigm manipulates objective memory attributes in terms of three types of memory content (people, objects, and places) associated to a particular “theme” word, and two levels of specificity (remembered conceptual gist- or perceptual detail-level information). Cooper and Ritchey (2022) examined the contribution of all of these objective memory attributes to subjective vividness ratings. They found that young adults relied on gist information to rate the vividness of event memories.

In addition to our key comparison of younger versus older participants, the present study additionally collected two separate types of subjective measures of memory; confidence judgements and vividness ratings. Confidence and vividness are frequently used interchangeably to describe the subjective experience of episodic memory. Nevertheless, they are two different concepts, capturing different aspects of memory experience. While vividness is associated with the highly variable ability to mentally visualize across individuals, confidence is more related to metacognition and thus the ability to evaluate one’s own cognitive ability (Fleming & Lau, 2014). A review of episodic memory phenomenology (Folville et al., 2021) emphasized the importance of examining memory vividness and memory confidence within the same task to understand the relationship between these two concepts in episodic memory. However, there is a scarcity of studies that utilise both subjective measures within a single paradigm. The only recent study to investigate the difference between the concept of vividness and confidence in episodic memory was carried out by Zou and Kwok (2022). They reported that repeated transcranial magnetic stimulation (TMS) of left angular gyrus reduced the trial-by-trial correspondence between objective memory performance and reported memory vividness, but not memory confidence. This emphasizes the importance of distinguishing between vividness and confidence when evaluating subjective memory experience. It may be of particular importance in ageing research, given the mixed results in terms of changes to metacognition in older adults (Siegel & Castel, 2019; Soderstrom et al., 2012), and the preserved or even increased memory vividness (Folville, Bahri, et al., 2020; Folville, D’Argembeau, et al., 2020).

The main purpose of this study was to investigate whether subjective memory vividness and confidence are reliant on conceptual gist and perceptual detail memory in a similar way among young and older adults. We hypothesized that conceptual gist scores will predict memory vivid-

ness ratings more strongly than perceptual detail scores, replicating the findings of Cooper and Ritchey (2022). Furthermore, we expected that the relationship between conceptual gist scores and memory vividness ratings will be stronger within the older adult group compared to the younger adult group. In regard to confidence, we expected that it will follow a similar pattern to vividness; conceptual gist scores will predict confidence ratings more strongly than perceptual detail scores and this relationship will be stronger in the older adults.

## Method

### Transparency and Openness

This research was preregistered at Open Science Framework (OSF): <https://osf.io/5vcpt>. Deidentified participant data and analytical code are available at OSF: <https://osf.io/ceq86>. The analytical code was based on the Cooper and Ritchey (2022) analysis code available at GitHub: <https://github.com/memobc/paper-vividness-features>, and extended to account for a between-subjects factor of age group and an additional dependent variable of confidence rating. The materials used can be made available upon request. Procedures were approved by the University of Sussex Sciences & Technology C-REC. A shortened example version of the paradigm can be accessed at <https://h02.eventmemory.org/example/instructions.html>.

### Participants

One-hundred young adults (47 females, 6 non-binary, 47 males) and 100 older adults (50 females, 50 males) participated. Seven participants were excluded under our preregistered exclusion criteria: 4 young adults and 3 older adults performed below a threshold of 30% correct for conceptual gist memory (chance = 25%). This resulted in a final sample size of 96 young adults aged 20-25 ( $M = 21.78$ ,  $SD = 1.67$ , 46 females, 6 non-binary, 44 males), and 97 older adults aged 68-75 ( $M = 71.59$ ,  $SD = 2.06$ , 50 females, 47 males). Demographic measures for both age groups are available in Supplementary Materials in Table S1. There was a greater variety in the achieved educational level in the older adult group. For this reason, we estimated linear mixed effect models to verify that vividness and confidence ratings, as well as overall memory performance, are predicted by the main variables of interest while controlling for participants' educational level, which was not a significant predictor. The results of this analysis can be found in Supplementary Materials in Tables S2-S4 available at <https://osf.io/ceq86>. All participants were United Kingdom residents.

### Measures

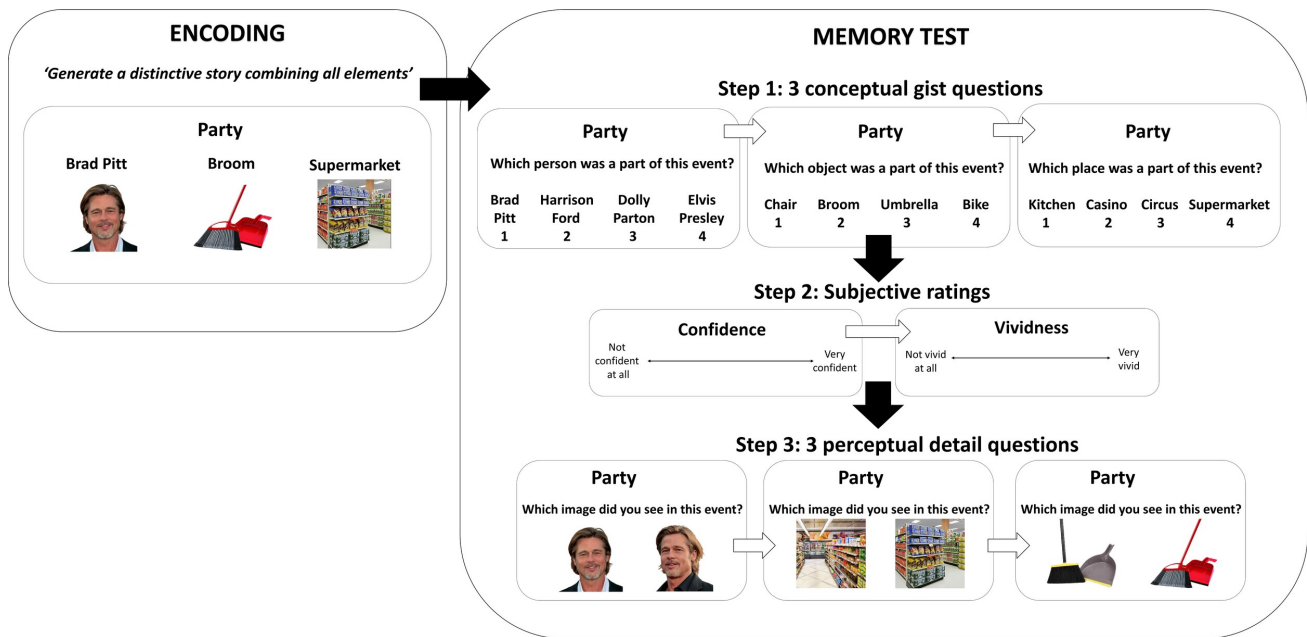
All participants completed the study in one online session, lasting approximately 45 minutes at a self-guided pace. See [Figure 1](#) for details of the experimental paradigm, which was based on Experiment 2 from Cooper and Ritchey (2022), coded using PsychoPy (Peirce et al., 2019) and stored on a privately hosted web-server. Instructions were provided in written and audio versions simultaneously, and

the first phase of the experiment started immediately after the instructions. The study consisted of four parts.

In the first part (encoding phase), participants were shown 24 stimuli sets, each comprising four elements, which constituted a single event. The elements were randomly assigned to one of the 24 events, but the combination of elements into events was fixed across participants. Each set contained a labelled photo of (1) a famous person, (2) an object, (3) a place, and (4) a theme word (e.g. "Party"), presented without a photo. Each element was uniquely associated with a single event. Famous person images were selected based on a pilot study, with participants in the same young and older adult age range as the current study, all of whom were United Kingdom residents. Participants were asked to generate a meaningful, distinct story to create an association between the elements in each stimuli set and then press the spacebar. The time limit was 20 seconds.

In the second part, the test phase instructions followed immediately after completion of the encoding phase. Confidence and vividness were defined using an example during test phase instructions. Participants were told that the ability to vividly visualise an event does not necessarily correspond to how confident one can be in the accuracy of their memory for that event. They were given an example in which a friend tells them that the last time they saw each other, they met in a café. One may be able to vividly visualise sitting inside that café. However, it may not correspond to how confident a person may feel that it really was the place they met their friend most recently. Conversely, it is possible to feel confident about the accuracy of one's memory without vividly re-experiencing the event. For example, a person may be sure that they last saw their friend in the café, without being able to vividly visualise it.

Memory for all 24 stimuli sets was tested and all test responses were self-paced. First, conceptual gist memory was tested, using a four-alternative forced-choice recognition test, separately for people, objects and places. A theme word was presented as a retrieval cue, together with four word labels of previously studied people, places or objects. One of the labels was associated with the event indexed by the theme word; the other three labels were from different events. Following this, participants were asked to rate how confident they were about their memory and how vivid their memory was using continuous scales, anchored between one and six. Afterwards, participants were tested on their perceptual detail memory using a two-alternative forced-choice recognition test. Each test trial comprised two conceptually identical and perceptually similar pictures of the same person, object or place; one of the pictures was identical to the studied image. The pictures shown in the perceptual detail memory test were always correct in regard to the theme word they were studied with, regardless of whether participants responded correctly to the conceptual gist questions. The test order for the three elements of content manipulation (person, place or object) was counterbalanced across trials but fixed for conceptual gist and perceptual detail questions within the same trial.



**Figure 1. Paradigm overview.**

During the encoding stage, participants were asked to generate a meaningful story with the theme presented as a word (e.g. "Party"), and containing the three elements presented on the screen. On every test phase trial, participants were shown the theme word as a retrieval cue. First, they were tested on conceptual gist-level memory, separately for person, place and object elements, using a four-alternative forced-choice recognition test. Next, they were asked to rate their subjective experience of memory using a continuous scale, first for confidence, and then for vividness. Finally, participants were tested on perceptual detail-level memory, separately for each element, by having to distinguish between two perceptually similar images.

In the third part of the study, participants indicated whether they recognized each of the famous people. Finally, the fourth step consisted of two questionnaires: Vividness of Visual Imagery Questionnaire (VVIQ, Marks, 1973) and the Survey of Autobiographical Memory (SAM, Palombo et al., 2013).

## Analyses

Following Cooper and Ritchey (2022), we carried out the original analysis as applied in their paper. Additionally, we analysed confidence ratings. Critically, we also investigated age as a between-subjects factor. The main analyses of interest focused on the trial-wise relationship between subjective ratings of confidence and vividness and objective memory attributes. This was done in two ways: using within-participant correlations between subjective memory ratings and each of the memory attributes, and predictive linear models with repeated cross validation exploring which memory attributes predict subjective memory ratings.

Additionally, we explored individual differences in the relationship between the subjective ratings and memory attributes. We calculated correlations between mean subjective memory ratings and two questionnaires - SAM and VVIQ. We also ran K-Means clustering analysis to group participants based on the similarity, defined as Euclidean distance, of the correlations between all memory attributes and the subjective memory ratings.

Furthermore, we conducted an exploratory generalised linear mixed-effects model which contained data from both subjective ratings and age groups within a single model.

The results of this analysis can be found in Supplementary Materials at <https://osf.io/ceq86>.

## Results

We first tested for differences in memory performance and subjective memory ratings between the two age groups. Older adults performed significantly worse than young adults on both conceptual gist and perceptual detail memory. This was measured using a Mann-Whitney U-test separately for conceptual gist and perceptual detail. Young adults remembered significantly more items at conceptual gist memory level ( $M_{\text{young}} = 2.31$ ,  $SD_{\text{young}} = 0.96$ ) than older adults ( $M_{\text{older}} = 2.04$ ,  $SD_{\text{older}} = 1.05$ ),  $U = 6085.0$ ,  $p < .001$ ,  $r = -0.31$ , as well as at perceptual detail memory level ( $M_{\text{young}} = 2.18$ ,  $SD_{\text{young}} = 0.82$ ,  $M_{\text{older}} = 2.07$ ,  $SD_{\text{older}} = 0.84$ ),  $U = 5606.5$ ,  $p < .05$ ,  $r = -0.20$ .

Older adults reported significantly lower memory vividness ratings ( $M_{\text{young}} = 3.28$ ,  $SD_{\text{young}} = 0.91$ ,  $M_{\text{older}} = 2.48$ ,  $SD_{\text{older}} = 0.94$ ),  $U = 2457.0$ ,  $p < .001$ ,  $r = 0.47$ , and confidence ratings ( $M_{\text{young}} = 3.75$ ,  $SD_{\text{young}} = 0.94$ ,  $M_{\text{older}} = 2.68$ ,  $SD_{\text{older}} = 1.05$ ),  $U = 2084.0$ ,  $p < .001$ ,  $r = 0.55$ , in contrast to young adults. Furthermore, there was a strong significant trial-wise correlation between confidence and vividness ratings within both young adults' group ( $r(2207) = 0.78$ ,  $p < .001$ ) and older adults' group ( $r(2230) = 0.90$ ,  $p < .001$ ).

For subsequent analyses, and following Cooper and Ritchey (2022), perceptual detail memory was set to incorrect if the answer to the corresponding conceptual gist element was incorrect within the same event. This is because detailed perceptual information, always tested on correct event elements, could not have contributed to the subjective



tive memory experience if the gist of the feature was not first successfully recalled. To verify that this decision does not affect the overall pattern of results, we have also run all analyses on data where detail memory performance was not set to be conditional upon gist memory performance. Out of 34 analyses, only one result has changed, with a correlation between detail memory for object and vividness ratings becoming significant in older adults when detail performance is not restricted to trials where gist memory is correct. The results of the verification analyses can be found at <https://osf.io/ceq86>.

We tested whether conceptual gist and perceptual detail memory for place, person and object are significantly correlated with vividness and confidence ratings, using one sample t-tests with Bonferroni correction (these correlations are shown in [Figure 2A](#)). These t-tests were performed separately for vividness and confidence correlations, and separately for young and older adults. Replicating Cooper and Ritchey (2022), conceptual gist memory for all three types of content (place, object, person) was significantly related to vividness ratings amongst young adults (mean  $z \geq 0.31$ ,  $ts(95) \geq 10.39$ ,  $ps < .001$ ,  $d \geq 1.06$ ). We found the same pattern for conceptual gist memory in older adults (mean  $z \geq 0.35$ ,  $ts(96) \geq 11.43$ ,  $ps < .001$ ,  $d \geq 1.16$ ). As in Cooper and Ritchey (2022), only perceptually detailed memory for the place was significantly correlated with memory vividness amongst young adults ( $z = 0.08$ ,  $t(95) = 2.85$ ,  $p < .05$ ,  $d = 0.29$ ), with person and object memory scores being non-significant ( $z \leq 0.07$ ,  $ts(95) \leq 2.31$ ,  $p \geq 0.14$ ,  $d \leq 0.24$ ). However, we did not find this relationship in older adults, with none of the perceptual detail memory attributes being significantly correlated with memory vividness ( $z \leq 0.06$ ,  $ts(96) \leq 2.13$ ,  $p \geq 0.21$ ,  $d \leq 0.22$ ). Nevertheless, there was no significant difference between the older and young adult groups' correlations of memory vividness and detail place memory,  $t(180.52) = 1.63$ ,  $p = 0.10$ ,  $d = 0.24$ .

Regarding confidence ratings, the results followed a nearly identical pattern to vividness. Conceptual gist memory for all three types of content was significantly related to confidence ratings in both young adults (mean  $z \geq 0.34$ ,  $ts(95) \geq 11.64$ ,  $ps < .001$ ,  $d \geq 1.19$ ), and older adults (mean  $z \geq 0.36$ ,  $ts(96) \geq 12.41$ ,  $ps < .001$ ,  $d \geq 1.26$ ). Perceptual detail memory for the place and object was significantly correlated with confidence ratings in young adults (mean  $z \geq 0.10$ ,  $ts(95) \geq 3.10$ ,  $ps < .05$ ,  $d \geq 0.32$ ), but not person detail memory (mean  $z = 0.03$ ,  $t(95) = 0.87$ ,  $p = 1.00$ ,  $d = 0.09$ ). None of the perceptual detail memory attributes were correlated with memory confidence in older adults (mean  $z \leq 0.07$ ,  $ts(96) \leq 2.22$ ,  $ps \geq 0.17$ ,  $d \leq 0.23$ ).

To test whether older adults rely on conceptual gist to a greater extent than young adults to assess their subjective memory experience while controlling for the effect of memory content, we also ran age (2 levels, between subjects: young adults, older adults)  $\times$  content (3 levels, within subjects: place, person, object)  $\times$  specificity (2 levels, within subjects: gist, detail) mixed effect ANOVAs, separately for confidence and vividness ratings. The dependent variable was the correlation between the subjective rating and the memory attributes. Across both subjective measures, there

was a significant main effect of specificity for vividness correlations,  $F(1, 191) = 193.48$ ,  $p < 0.001$ ,  $\eta^2_G = 0.195$ , and confidence correlations,  $F(1, 191) = 198.99$ ,  $p < 0.001$ ,  $\eta^2_G = 0.207$ . There was no significant main effect of age or content, and no significant two-way interactions between specificity and age on vividness or confidence correlations.

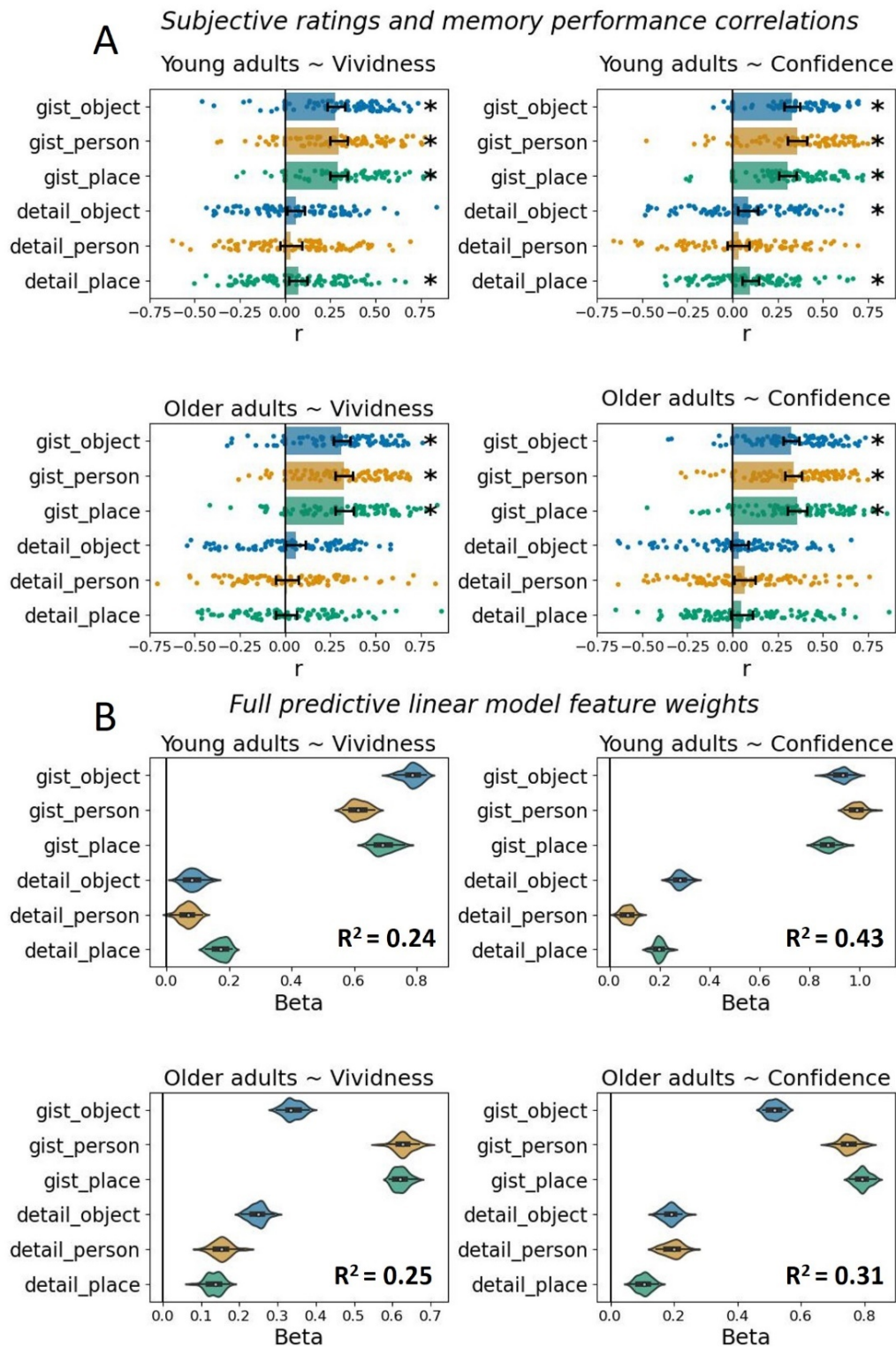
Following Cooper and Ritchey (2022), we used a predictive linear regression procedure to predict subjective ratings using performance on the six memory attributes (these results are shown in [Figure 2B](#)). We replicated the pattern of results for vividness ratings of young adults. We defined the best model as the one with the highest out-of-sample R-squared value. We identified the best model to predict vividness ratings included four memory attribute predictors: conceptual gist memory of object, place and person, as well as perceptual detail memory for place (highest out-of-sample R-squared = 0.24;  $SD = .04$ ). The best model to predict young adults' confidence ratings included all three conceptual gist elements, as well as perceptual detail memory for object and place (highest out-of-sample R-squared = 0.43;  $SD = .04$ ).

For older adults, the best model containing all six memory attributes as predictors explained the most variance in both vividness ratings (highest out-of-sample R-squared = 0.25;  $SD = 0.04$ ) and confidence ratings (highest out-of-sample R-squared = 0.31;  $SD = .04$ ).

## Individual differences

Given the substantial individual variability in the findings of Cooper and Ritchey (2022), we also explored individual differences in the relationship between the subjective ratings of confidence and vividness and memory attributes. First, we conducted correlations between mean subjective memory ratings (separately for confidence and vividness) and each of the memory attributes, as well as scores on the two questionnaires - the episodic component of the Survey of Autobiographical Memory (SAM-episodic; Palombo et al., 2013) and the Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973). These correlations were evaluated at a one-tailed Bonferroni-corrected threshold of  $r = 0.233$ , expecting a positive correlation between the scores on the questionnaires and the mean subjective memory ratings.

Cooper and Ritchey (2022) reported significant but weak correlations between mean memory vividness ratings and both the SAM score, as well as the VVIQ score. Furthermore, in their study, mean vividness scores were correlated with all six memory attributes, although to a greater extent with the conceptual gist memory attributes than with the perceptual detail memory attributes. The current study partially replicated Cooper and Ritchey (2022), as shown in [Figure 3](#). In the young adult group, there was a weak but significant correlation between mean memory vividness ratings and the SAM-episodic questionnaire scores, but not the VVIQ scores. Neither questionnaire was correlated with mean memory confidence ratings in young adults. In the older adult group, mean vividness and confidence ratings were significantly correlated with SAM-episodic scores ( $rs \geq 0.33$ ). Furthermore, mean memory vividness but not



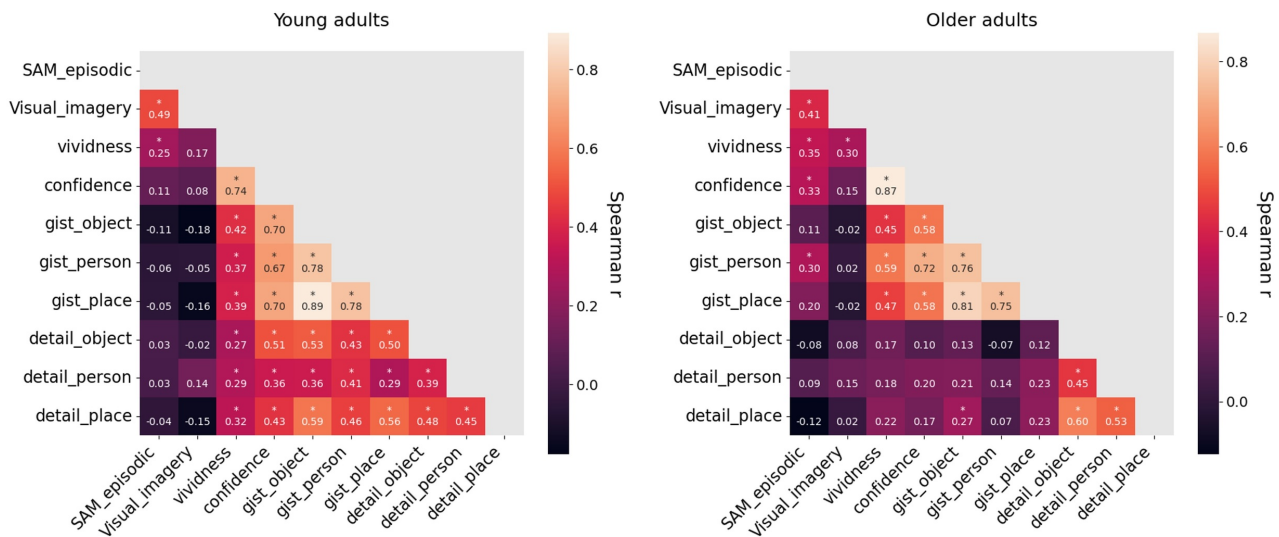
**Figure 2. Within-participant correlations and the predictive model beta coefficients of the relationship between subjective and objective memory measures.**

(A) Within-participant correlations between subjective memory ratings and memory attributes. \* indicates  $p < 0.05$ , Bonferroni-corrected. Perceptual detail correlations are restricted to trials where the conceptual gist was correct. Bars indicate the mean  $\pm$  95% CI. (B) The beta coefficients of memory attributes included in the full predictive model. The violin plots show the range of beta values obtained across the 50 train-test splits. Out-of-sample R-squared of the full model containing six predictors is shown in bold in the right corner.

mean memory confidence was correlated with the VVIQ scores ( $r = 0.30$ ). Amongst older adults, there was a weak but significant correlation between the SAM-episodic score and gist person memory performance ( $r = 0.30$ ), but none of the other five memory attributes. VVIQ scores were not

significantly correlated with any of the memory attributes amongst older adults, similarly to the results obtained in the young adults group.

Replicating the original study, young adults' mean vividness scores were significantly correlated with all conceptual



**Figure 3. Between-participant correlations of memory measures and questionnaires.**

Spearman  $r$  correlation coefficients between each measure. \* indicates  $p < 0.05$ , Bonferroni-corrected.

gist memory attributes ( $r_s \geq 0.37$ ) and perceptual detail memory attributes ( $r \geq 0.27$ ). Mean confidence ratings were also significantly correlated with all conceptual gist memory attributes ( $r_s \geq 0.67$ ) and perceptual detail memory attributes ( $r_s \geq 0.36$ ). We found no correlation between young adults' mean memory performance on any of the six memory attributes and the two questionnaires.

Both mean memory vividness and confidence were significantly correlated with all three gist memory attributes in older adults ( $r_s \geq 0.45$ ). However, we found no significant correlations between mean vividness or confidence ratings and detail memory attributes.

Second, we performed K-Means clustering to group participants based on the similarity (Euclidean distance) of the correlation between all memory attributes and subjective memory measures. To obtain the optimal number of clusters ( $k$ , up to a maximum of 10), we identified the elbow of the curve for inertia values, defined as the sum of squared distances of each participant to their closest cluster centre. For each  $k$  iteration, K-Means was run 500 times, returning the cluster assignments with the lowest inertia. K-Means clustering was run separately for confidence and vividness, and separately for older and young adults.

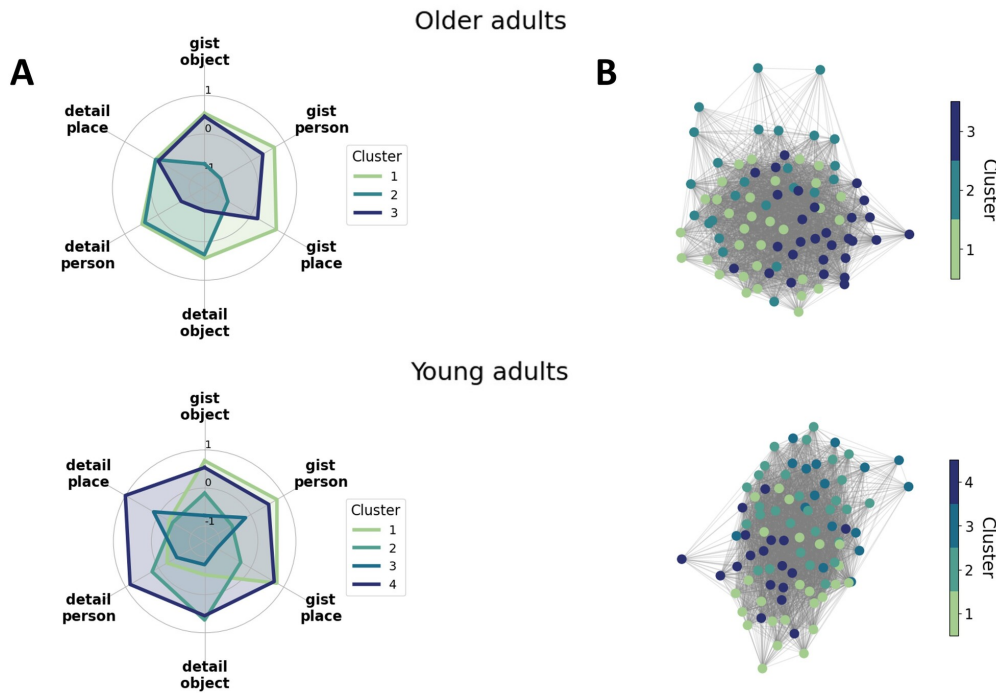
Cooper and Ritchey (2022) reported that even though young adults' subjective sense of vividness is more closely tied to gist over detail memory at a group level, there are individual differences in that pattern. Using K-Means clustering analysis, they found that participants were clustered into 3 groups. One group showed an equally strong relationship between vividness ratings and all conceptual gist and perceptual detail memory attributes combined, a second group showed a stronger relationship between vividness ratings and conceptual gist memory attributes, and the final group showed a stronger relationship between vividness ratings and perceptual detail memory attributes. We found a similar pattern of results, though with a varying number of clusters throughout the analyses.

The following graphs shown in Figure 4 represent participant clusters from K-Means analysis, which grouped the participants based on their pattern of correlations between vividness memory ratings and the six memory attributes. The results of analyses ran on confidence ratings can be found in Supplementary Materials in Table S5 and in Figures S2-S5. All correlations were z-scored. Note that outliers were identified and removed before the analysis was run for each group and each dependent variable. Outliers were identified as participants with any z-scored memory score with an absolute value greater than 2.5. For the number of participants included in each analysis please see Supplementary Table S5.

Older adults showed a similar pattern of individual differences to the young adult sample in Cooper and Ritchey (2022), with the optimal number of clusters identified being three. The first cluster ( $N = 32$ ) showed a strong relationship between vividness ratings and all six memory attributes; the second cluster ( $N = 25$ ) showed a stronger relationship between vividness ratings and the place, object, and person elements of perceptual detail memory; and the third cluster ( $N = 29$ ) revealed a stronger relationship between vividness ratings and the place, object and person elements of conceptual gist memory as well as detail place memory. The clusters did not differ in their relationship between vividness ratings and detail place memory.

In the young adult sample from the current study, we identified four clusters. The first cluster ( $N = 25$ ) showed a stronger relationship between vividness ratings and conceptual gist memory of place, object and person elements; the second cluster ( $N = 29$ ) between vividness ratings and perceptual detail memory of object elements; the third cluster ( $N = 17$ ) had a very limited relationship with memory attributes overall; and the fourth cluster ( $N = 18$ ) showed a strong relationship between vividness ratings and all six memory attributes.





**Figure 4. Memory profiles, showing clusters of participants based on similarity in attribute-to-vividness correlation patterns.**

(A) Polar plots showing the cluster centroid values (z scores) of the correlations between memory vividness and the six memory attributes in both age groups. (B) The Euclidean distance between each participant (node) based on their attribute-to-vividness correlations, showing 80% of edges for visualization and with participants color-coded by cluster assignment.

## Discussion

This study aimed to establish whether the relationship between objective and subjective measures of memory is consistent across the lifespan, both when considering memory at the level of conceptual gist, as well as perceptual detail. We found that older adults performed at a lower level than young adults, yet the correspondences between objective measures and vividness and confidence ratings (our subjective measures), were very similar across both age groups. Both young and older adults rely on gist to a greater extent than detail to judge their subjective memory experience, which replicates and extends the results of Cooper and Ritchey (2022) who demonstrated this effect in young adults. Contrary to some previous studies, we neither found that older adults were spared in their gist-based memory, nor that vividness ratings were higher in the older adults. Across both age groups, the greater reliance on conceptual gist follows a similar pattern across vividness and confidence ratings, with the two subjective measures being strongly correlated. Our results suggest that throughout the lifespan, the amount of conceptual information retrieved about an event relates to the ability to reexperience it vividly, and to have confidence in one's memory.

Our key new finding is that the relationship between objective and subjective measures of memory was the same in both the younger and the older age groups. Similarly to younger adults, the older adults predominantly based both ratings of memory vividness and confidence on the retrieval of conceptual gist-level information about the events. In-

terestingly, while objective levels of performance were lower in the older adults, this was mirrored by lower ratings of vividness and confidence. This suggests that older and younger adults base their phenomenological experience of remembering on the retrieval of qualitatively similar information. Furthermore, this reliance on conceptual gist-level information supports the view that a coherent memory trace involves the binding of primarily gist-level information about distinct features of an event. In contrast, accessing the perceptually detailed information about each feature appears to be a separate, independent process (Cooper & Ritchey, 2019; see also Andermane et al., 2021).

We found little difference between subjective ratings of vividness and confidence, with both being predicted by conceptual gist memory to a greater extent than perceptual detail memory. During the test phase instructions, confidence was defined in terms of belief in how accurate the memory was, whereas vividness was defined in terms of the ability to visualise an event in our mind's eye. Nevertheless, both within-subject and between-subject ratings of confidence and vividness were highly correlated (Figure 2 and Figure 3; see also Robinson et al., 2000, and Sharot et al., 2007, for similar findings when rating autobiographical memories). It remains an open question whether there are situations when the subjective experiences of memory confidence and memory vividness dissociate (for further discussion, see Folville et al., 2021).

In our study, the older adults performed more poorly on the episodic memory tasks, both at the level of conceptual gist and perceptual detail. This is somewhat at odds with



previous studies reporting that gist memory remains intact amongst older adults (for reviews, see Devitt & Schacter, 2016; Grilli & Sheldon, 2022). For example, older adults often retain information at a superordinate level or they retain information about prototypical details, but are poorer at remembering specific details (Flores et al., 2017). In addition, when testing memory for complex, structured material, such as stories or TV shows, the main ideas of the storyline were well-retained in older adults, but they were poorer at remembering literal or perceptual details (Adams et al., 1997; Delarazan et al., 2023). It has been argued that older adults use their schematic knowledge to interpret and remember key information about their experiences, but remember fewer specific details (see also Amer et al., 2022; Grilli & Sheldon, 2022; Umanath & Marsh, 2014). In our study, participants had to create a novel association between a famous person, object and a place, thus not allowing older adults to maintain their performance via the use of pre-existing schemas. Moreover, “gist-level” in our study still referred to specific elements (individuals, objects, and locations) rather than more categorical or superordinate classes of elements (e.g. actors, tools, and interiors).

Older adults often report equally high or even higher experiences of vividness when rating their memories compared to younger adults, even if their objective performance on memory tests is poorer (Folville, Bahri, et al., 2020; Folville et al., 2021). We did not find this; older adults’ subjective ratings were significantly lower than those of younger adults, and this was in line with their poorer performance on the task. Interestingly, studies that reported the overestimation of vividness amongst older adults used free recall (Folville, D’Argembeau, et al., 2020; Robin & Moscovitch, 2017). By contrast, our forced-choice recognition procedure may have influenced our participants’ subjective ratings of their memories. Older adults may have monitored their subjective memory experience by knowing that one of the choices they were presented with was correct and yet they did not recollect it. Nevertheless, the existing literature on the impact of ageing on memory monitoring (“metamemory”) is not clear-cut. A number of previous studies assessing judgements-of-learning and monitoring of forgetting found either negligible or non-existent differences between young and older adults (Halamish et al., 2011; Hertzog et al., 2010; Hines et al., 2009). In contrast, age-related declines have been reported using a different assessment of metamemory (episodic memory “feeling-of-knowing”; Souchay et al., 2000).

Subjective experience of memory and imagination varies substantially even among young people (D’Argembeau & Var der Linden, 2005). Moreover, ageing amplifies individual differences in cognitive abilities (Rabbitt, 2019). Therefore, ageing research should consider not only group-level differences between young and older adults, but also within-group individual differences. We explored the relationship between memory performance and subjective memory experience across the lifespan using clustering analyses. We identified three clusters in the older adult group: one relied more heavily on conceptual information to inform their subjective vividness judgement, one more

on perceptual detail information, and the third relied on both conceptual and perceptual detail information. This is very similar to the findings of Cooper and Ritchey (2022) in young adults. In our young adult group, we identified four clusters: one cluster showed a stronger relationship between vividness ratings and conceptual gist memory, the second cluster with perceptual detail of object elements, the third had a very limited relationship with memory attributes overall, and the fourth cluster showed a strong relationship between vividness ratings and all six memory attributes. An interesting avenue for future research would be to investigate whether these individual differences in behaviour can be identified at a neural level. Self-reported individual differences have been related to differences in medial temporal lobe (MTL) connectivity (Sheldon et al., 2016). The posterior brain regions underlying visual-perceptual processing have been associated with the scores on the SAM episodic subscale, and the inferior and middle prefrontal cortical regions with the SAM semantic subscale (Sheldon et al., 2016). Given our findings, individual variability in the relationship between episodic memory performance and its phenomenology should be taken into consideration when investigating the neural underpinnings of memory vividness.

In our procedure, the conceptual gist-level questions were always presented first, followed by subjective ratings and then the perceptual detail questions. It is possible that both age groups anchored their subjective ratings on their performance on the gist memory question, and this may explain the correspondence between the subjective measures and gist memory performance. However, this explanation is not supported by the findings from the first experiment conducted by Cooper and Ritchey (2022), where participants were asked to rate their memory’s vividness first, before being tested on conceptual gist or perceptual detail memory. In this experiment, we found the same relationship between conceptual gist memory performance and vividness ratings. Nevertheless, collecting vividness ratings before testing memory resulted in generally low vividness ratings, whereas if conceptual gist memory was tested first, there was a larger range in vividness ratings and they were also generally higher.

Another aspect of our design was the collection of both gist and detail memory measurements for every trial, which permitted within-subjects analyses of how these measures are mutually related to vividness. The order of the memory tests was fixed, with gist-level questions always preceding detail-level questions. This was necessary because perceptual detail questions were always tested on the correct conceptual-level item. For example, if “Brad Pitt” was the person element within an event, then the perceptual detail question always showed two similar photos of Brad Pitt, irrespective of whether the participant correctly identified Brad Pitt as being the person present in the event. Consequently, it would not be possible to test gist memory after revealing the correct answer in the perceptual detail memory test. Future research could incorporate testing the conceptual gist memory and perceptual detail memory on separate events, or test gist memory across all trials before

testing perceptual detail memory afterwards, to overcome this limitation. Overall, the current study does not provide evidence for the overestimation of vividness and confidence amongst older adults, and demonstrates that healthy older adults are capable of monitoring their subjective memory experience effectively when tested on a recognition memory task.

In conclusion, we show that both older and younger adults show a close correspondence between their ability to recognise gist-level conceptual information about events and their subjective ratings of how well they can remember these events. By contrast, the ability to recognise more fine-grained perceptual features of events is largely unrelated to the subjective experience of remembering, across both age groups. Unlike several previous studies using different memoranda and procedures, we neither observed increased memory vividness ratings in the older adults, nor a relative preservation of gist-level memory performance. Overall, this study provides evidence suggesting that the relationship between memory performance and subjective memory experience remains mostly stable across the lifespan. Nevertheless, the links between objective measures of memory and the phenomenological experience of remembering are only beginning to be understood and provide an exciting new direction for understanding the multifaceted ability that recollecting the past is.

### Author Contributions

Contributed to conception and design: M.R., K.M.M., C.M.B., F.D.L.

Contributed to acquisition of data: K.M.M.

Contributed to analysis and interpretation of data: K.M.M., S.C.B., C.M.B., M.R.

Drafted and/or revised the article: K.M.M., C.M.B., F.D.L.

Approved the submitted version for publication: K.M.M., C.M.B., F.D.L., S.C.B., M.R.

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### Competing Interests

No competing interests exist for all authors of this submission.

### Data Accessibility Statement

The hypotheses, design and the analysis plan of this study were preregistered at <https://osf.io/5vcpt>. The deidentified data and analyses scripts can be found at Open Science Framework (OSF): <https://osf.io/ceq86>. The stimuli used can be made available upon request.

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