Full-Length Research Report

Interindividual Differences in Cognitive Functioning Are Associated with Autobiographical Memory Retrieval Specificity in Older Adults

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Abstract: We examined whether interindividual differences in cognitive functioning among older adults are related to episodic memory engagement during autobiographical memory retrieval. Older adults (n = 49, 24 males; mean age = 69.93; mean education = 15.45) with different levels of cognitive functioning, estimated using the Montreal Cognitive Assessment (MoCA), retrieved multiple memories (generation task) and the details of a single memory (elaboration task) to cues representing thematic or event-specific autobiographical knowledge. We found that the MoCA score positively predicted the proportion of specific memories for generation and episodic details for elaboration, but only to cues that represented event-specific information. The results demonstrate that individuals with healthy, but not unhealthy, cognitive status can leverage contextual support from retrieval cues to improve autobiographical specificity.

Keywords: Autobiographical memory, episodic memory, fluency, recollection, interindividual differences

Introduction

As individuals age, autobiographical memory – the ability to recollect one's own personal history – changes over time (Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002; Nyberg, Bäckman, Erngrund, Olofsson, & Nilsson, 1996; Nyberg et al., 2003; Piolino, Desgranges, Benali, & Eustache, 2002). Research indicates that cognitive aging disproportionately targets the episodic component of autobiographical memory, leaving semantic processes intact. Given that episodic processes support the specificity of autobiographical retrieval, i.e., the recollection of contextualized events and their associated details, one might expect retrieval specificity deficits in older adults. However, within this population, there are substantial differences in global cognitive functioning that can influence how memory tasks are performed (Dennis, Bowman, & Peterson, 2014; McIntyre & Craik, 1987; Spencer & Raz, 1995). Indeed, studies have labelled some older adults as "low cognitive performers" and some as "high cognitive performers" based on whether they perform encoding and retrieval tasks at a level comparable to their younger adult counterparts (Cabeza et al., 2018; Glisky, 2007; Lighthall, Huettel, & Cabeza, 2014; Van Petten, 2004; Van Petten et al., 2004). While previous research has contrasted autobiographical retrieval specificity between healthy older adults and those with pathological cognitive deficits (e.g., amnestic mild cognitive impairment [aMCI] or Alzheimer's disease; Addis & Tippett, 2004; Barnabe, Whitehead, Pilon, Arsenault-Lapierre, & Chertkow, 2012; Donix et al., 2009; Leyhe, Müller, Milian, Eschweiler, & Saur, 2009; Matuszewski et al., 2009; Murphy, Troyer, Levine, & Moscovitch, 2008), it remains unclear whether differences in cognitive functioning among healthy older adults is associated with autobiographical retrieval specificity. The current study assesses whether interindividual differences in cognitive functioning within an older adult sample relates to the specificity of autobiographical memory retrieval, a metric of episodic memory engagement. Ultimately, we aimed to understand whether differences in autobiographical specificity can distinguish between healthy and unhealthy aging trajectories in preclinical older adults.

Autobiographical memory retrieval requires accessing event-related information from different levels within a

knowledge base or hierarchical structure. This knowledge base is organized such that specific, contextualized event information is embedded within broader conceptual or semantic elements of an experience (Conway, 2005; Conway & Pleydell-Pearce, 2000). Age differences in episodic memory influence the ability to access and associate together the specific, perceptually based elements of a past event when constructing an online representation of a recollected experience ("elaboration" retrieval; Levine et al., 2002; Peters, Fan, & Sheldon, 2019; Piolino et al., 2010; Sheldon, McAndrews, & Moscovitch, 2011; Sheldon et al., 2015). A number of studies demonstrated that, compared to younger adults, older adults provide fewer specific episodic details (*"I was wearing a blue scarf. It was raining that day"*) when describing past events, instead incorporating more personal or general semantic aspects of the experience (*"I love travelling," "Paris is the capital of France"*; Addis, Roberts, & Schacter, 2011; Levine et al., 2002; Sheldon et al., 2011; although see Aizpurua & Koutstaal, 2015). Interestingly, age differences in episodic memory ability may also influence the ability to access and associate together multiple specific (i.e., episodic) event representations within the autobiographical knowledge structure ("generation" retrieval). Experiments using autobiographical fluency measures found that, when presented with a memory cue, healthy older adults tend to retrieve significantly fewer specific episodic events (*"Visiting the Eiffel Tower Last Summer")* and more repeated/extended events (*"Travelling in my 20s," "Travelling to France")* than younger adults (Peters et al., 2019; Piolino et al., 2002). Differences in autobiographical specificity among older adults at the level of events have been interpreted in different ways. One line of work linked this deficit to age-related episodic memory deficits (e.g., Peters et al., 2019), a proposal supported by neuroimaging research (Sheldon, McAndrews, Pruessner, & Moscovitch, 2016; Sheldon & Moscovitch, 2012). Another body of work suggested different mechanisms might underlie the ability to access specific autobiographical information at the level of event versus detail (Kyung, Yanes-Lukin, & Roberts, 2016; Piolino et al., 2010; Roberts, Yanes-Lukin, & Kyung, 2018). Thus, there remains open questions as to whether cognitive functioning in older adults relates to the specificity of autobiographical memory when generating episodic events versus elaborating on the details of a single recollected experience.

When studying the association between cognitive functioning and autobiographical specificity, it is important to consider the cue used to trigger retrieval as memory cues can direct access to different levels of the autobiographical knowledge structure. For instance, a memory cue can direct access via a higher level, when general thematic information is activated by the cue or, from a lower level, when event-specific knowledge is activated (Sheldon & Chu, 2017). In terms of cognitive status, empirical evidence suggests that older adults with superior cognitive ability can flexibly leverage information contained within an environmental cue (e.g., a context) to more effectively approach a given task (Craik, Klix, & Hagendorf, 1986; Craik & McDowd, 1987; Craik & Schloerscheidt, 2011). By comparison, older adults with lower cognitive functioning may not be able to engage in such flexible behavior and are, therefore, unable to benefit from the support provided by external cues. These effects have been demonstrated both when older adults encode new information (Dando, 2013; Verhaeghen, Marcoen, & Goossens, 1992) and when they retrieve laboratory-based stimuli (Craik & Byrd, 1982). However, it is not yet known whether healthy older adults can effectively leverage external support to compensate for episodic memory decline in the context of naturalistic autobiographical memory retrieval.

Based on the above-described model of autobiographical memory organization, we propose that, when a retrieval cue directs access to event specific knowledge (i.e., contextual or perceptual elements of an experience), the cue can be leveraged to activate episodic information about the recollected event, improving the specificity of autobiographical memory. In healthy older adults, we propose that high but not low cognitive performers are able to benefit from the external support provided by this type of retrieval cue. In the present study, we restricted our focus to two types of memory cues that direct access to different levels in the structure of autobiographical memory knowledge. Open-ended cues are those that trigger retrieval via higher-order semantic information and are thought to represent a wide variety of conceptually related experiences. For example, the cue "celebrating" can trigger the reactivation of a diverse array of past events (e.g., a birthday party, dancing in the kitchen, a drink with a friend) that are, nonetheless, all related to the concept of "celebrating." Conversely, when a retrieval cue is closed-ended, it triggers retrieval via the more episodically specific information shared among the associated events (e.g., an action or environmental context). For example, the retrieval cue "restaurant" reactivates past experiences situated within this specific environmental context. Given that autobiographical retrieval is a complex task, it is important to examine how (or if) cue type influences the relationship between autobiographical specificity and cognitive functioning across different forms of retrieval.

We propose that, during event generation, autobiographical memory retrieval cued by open-ended cues will benefit from semantic processing to guide access to specific episodic information via the abstracted, conceptual links between events. By comparison, when the generation of events is guided by episodically specific information

(i.e., closed-ended cues), we expect autobiographical specificity in older adults with low cognitive functioning will suffer because this task disproportionately relies on episodic memory processes. By comparison, during elaboration retrieval, open-ended cues can leverage higher-order conceptual information to access and bind together the specific, episodic details of a recollected event – akin to "top-down" processing. This may not be the case for closed-ended cues, which necessarily require episodic processes to access and bind together episodic details in a more "bottom-up" fashion, as guided by the specific contextual or perceptual information represented in the cue. This framework makes specific predictions about where interindividual differences in cognitive functioning are most strongly related to the specificity of autobiographical memory, namely, during elaboration retrieval to closed-ended cues, where episodic demands are highest. Clarifying the nature of the relationship between interindividual differences in cognitive functioning and the specificity of autobiographical memory has the two-fold benefit of providing a more comprehensive understanding of age differences in autobiographical memory retrieval and in identifying a behavioral marker of poor or unhealthy cognitive status.

Current Study

The present study investigates how interindividual differences in cognitive functioning among older adults relates to the specificity of autobiographical memory during two types of autobiographical memory retrieval. To this end, we recruited a sample of healthy older adults with subclinical differences in cognitive functioning, as estimated by the Montreal Cognitive Assessment (MoCA; Nasreddine et al., 2005). We used linear mixed-effects modeling to examine the relationship between cognitive functioning and autobiographical specificity during a generation retrieval task, where participants retrieved multiple related events; and an elaboration retrieval task, where participants described a single recollected event in detail. Importantly, we asked whether this relationship was modulated by the nature of the retrieval cue by presenting participants with both closed-ended and open-ended retrieval cues. First, we predicted that, if interindividual differences in global cognitive functioning capture episodic memory ability, these differences will be related to measures of autobiographical retrieval specificity. Second, we predicted that cognitive functioning would be associated with retrieval specificity both when accessing related autobiographical event representations (generation) and when integrating the details of a single event representation (elaboration). Third, we predicted that, across retrieval tasks, high cognitive performance would be associated with improved specificity of autobiographical memory when cued with event-specific information (close-ended cues) but not when cued with high-order semantic memory information (open-ended cues).

Materials and Method

Participants

Forty-nine older adults were recruited from the Montreal area via flyers distributed in the community and via advertisements in local newspapers. Our planned sample size (n = 50) was based on prior related research investigating interindividual (Baudouin, Vanneste, Isingrini, & Pouthas, 2006; Craik, Eftekhari, Bialystok, & Anderson, 2018) and group differences (D'Angelo et al., 2016) in cognitive functioning. Although this sample included individuals with a broad range of global cognitive ability, none of the recruited participants had a formal diagnosis of dementia, aMCI, or any other neurological disorders associated with overt cognitive deficits. All participants had normal or corrected-to-normal vision and hearing, spoke English fluently, were free from major medical complaints, and lived independently (i.e., without external community support or assistance). We excluded participants who had a history of concussion or other head trauma as well as those reporting a significant past or current psychiatric history. Crystallized intelligence and vocabulary were estimated using the Shipley Vocabulary Test (Schear & Harrison, 1988). All participants were above the suggested cut-off for healthy aging (a score of 33 out of 40; Mason & Ganzler, 1964). Participants gave informed consent and received monetary compensation for being part of the study. Table 1 displays the average demographic characteristics as well as estimates of intelligence and cognitive functioning for all participants. For a detailed breakdown of demographic and neuropsychological characteristics as a function of global cognitive status, please see Table E1 in the Electronic Supplemental Material (ESM 1).

Stimuli

Eight retrieval cues were collected from previously published reports (Peters et al., 2019; Levine et al., 2002; Sheldon & Chu, 2017; see Table 2). Of these eight cues, half were closed-ended in that they direct access to event-specific knowledge (i.e., contextual or perceptual elements of an experience). In other words, they trigger retrieval of perceptually related events and, as such, are predicted to result in the retrieval of highly similar event representations. The remaining cues were open-ended in that they direct access to higher-order semantic information (i.e., activity themes) shared among the associated events.

Table 1. Demographic characteristics and estimates of cognitive functioning for the tested cohort (n = 49; 24 males)

	Mean	*SD*	Median	Range
Age (years)	69.93	4.98	70	59–86
Education (years)	15.45	3.93	15	10–30
Shipley (/40)	34.63	3.63	35	33–40
MoCA Total (/30)	25.82	2.86	26	16–30
MoCA Memory (/5)	3.35	1.52	4	0–5
MoCA Executive (/5)	3.82	1.09	4	1–5
MoCA Fluency	14.6	4.89	16.5	6–28

Table 2. Retrieval cues used in the current study

Open-ended cues	Closed-ended cues
Time when you were Celebrating	Times when you were at Home
Times when you were at Galleries	Times when you were at the Mall
Times when you were Travelling	Times when you were at the Office
Times when you made Accomplishments	Times when you were Eating

Such cues are predicted to trigger the retrieval of a wide variety of conceptually related experiences. Cue categorization was based on ratings provided by 50 online older adult participants recruited from Amazon's Mechanical Turk (MTurk). MTurk participants were shown each cue in sequence and asked to judge the number of unique events that could be represented by that cue (Likert scale: 1 [*few events*; similar to one another] to 4 [*many events*; different from one another]). After removing data from three raters who provided incomplete or invalid responses, we were left with a final sample of 47 MTurk participants (22 males, age: M = 63.1 years, SD = 6.08; education: M = 15.3 years, SD = 2.75), and from these data we calculated the average rating for each cue. Using a median-split, cues that received high ratings (i.e., associated with many distinct events) were classified as "open-ended" and those that received low ratings (i.e., associated events are similar/overlapping) were classified as "closed-ended." As expected, the average MTurk rating was significantly greater for the open-ended (M = 2.97, SD = 0.47) than for the closed-ended cues (M = 2.04, SD = 0.64; $t_{(46)}$ = 9.54, $p < .001$, Cohen's d = 1.39).

Experimental Procedure

In an initial screening session, approximately 1 h in length, participants completed a demographics questionnaire, a language screening questionnaire, the Shipley Vocabulary test, and the MoCA cognitive screener. The latter is comprised of 30 items that provide an estimate of executive functioning, memory, language, abstraction, attention, and orientation. The sum of total responses on these items provides a metric of global cognitive ability. The MoCA memory subscale consists of a standard wordlist learning task with 1-point awarded to each correctly recalled word after a short (~ 5 minute) delay (maximum of 5 points can be awarded). The MoCA executive function subscale consists of a set-switching task (Trails B) and two visuoconstructive tasks (cube-copy and clock-drawing tests), and performance on these tasks is summed (to a maximum of 5 points) to generate an estimate of executive functioning performance. The MoCA "F" phonemic fluency task is folded into the language subscale but is considered separately in the present study. In this task, participants have 60 s to retrieve as many words as possible beginning with the letter "F." Language, abstraction, attention, and orientation subscales were not considered independently in the present study. For details we refer readers to Nasreddine and colleagues (2005).

Participants completed the experimental task in a single session, 1–5 days after the initial screening session. The experiment was presented via Eprime software (Version 2.0; Psychology Software Tools, Pittsburgh, PA). Detailed instructions were presented to the participants both visually and orally, and all participants completed two practice trials, identical in structure and timing to the experimental trials before beginning the experiment. Participants received detailed feedback on their performance and proceeded to the experimental trials only if it was clear they had understood and could comply with task instructions.

Generation Task

Over a series of eight trials, participants were presented with open-ended and closed-ended cues on the computer screen and were given 90 s to generate as many specific past personal events as possible to each cue (Dritschel, Williams, Baddeley, & Nimmo-Smith, 1992). Participants were told that a specific event was one that took place in a particular location, lasting minutes or hours but not longer than a single day (e.g., *"Going to the park for my 10th birthday"*). These instructions remained on the screen throughout the generation task. Participants provided a short verbal statement to describe each retrieved event, and all responses were both audio-recorded and written down by the experimenter. If the participant stopped producing responses during the 90-s fluency period, they were given a general prompt (*"Can you think of another memory?"*). If they began generating nonspecific responses, they were given a specificity prompt (*"Think of a more specific memory"*). For scoring purposes, all generation task responses were later transcribed verbatim from the audio recordings.

Elaboration Task

After the 90-s fluency period had elapsed, participants were shown a list of their previously generated events (written down by the experimenter) and asked to select one event per cue to elaborate upon in detail. Importantly, participants were instructed to select a specific event that they could remember clearly. If participants did not generate any specific event to a given cue, they were instructed to use one of their general responses to generate a specific event to subsequently elaborate upon. For instance, if they chose *"Going to the beach in my teenage years,"* they were instructed to *"Bring to mind a specific instance or example of a time that you went to the beach as a teenager."* Once an event was retrieved, it was shared with the experimenter for verification before proceeding. In short, all events included in the elaboration task were specific in time and place. Once a specific event had been selected, participants were given 3 min to describe the memory in as much detail as possible. Instructions remained on the screen throughout the elaboration task. If participants began describing a different event or general/factual information, a single prompt was given *("Try to describe only the details of the chosen event, and be as specific and detailed as possible")*. Memory descriptions were audio recorded and later transcribed verbatim for scoring.

For each detailed event description, participants provided ratings of vividness (0 = *not at all vivid* to 100 = *extremely vivid*), familiarity (0 = *not at all familiar* to 100 = *extremely familiar*), and estimates of when the event occurred (1 = *past week*, 2 = *past year*, 3 = *1–5 years*, 4 = *5–10 years*, 5 = *> 10 years old*, 6 = *I don't know*).

Scoring

Generation Task

The transcribed responses were categorized as either specific or nonspecific events using the Autobiographical Memory Test scoring (AMI) procedure (Williams & Broadbent, 1986). According to this procedure, specific responses capture events that occurred in a particular place and within a defined time period (minutes or hours but less than one day, e.g., "*bowling with my niece last June*"). Nonspecific responses are those that describe an event lasting longer than 1 day (extended event. e.g., *"my trip to Paris"*), multiple events occurring in the same location (repeated event, e.g., "*going to the gym every Saturday*"), general semantic information (e.g., "*I am generally a happy person*"), or repetitions of responses generated previously to the same cue. Coders were trained on an independent set of data (responses to the practice trials) and scored events as outlined in the AMI procedure. Two independent coders blind to the experimental design scored all generation task data. Given the categorical nature of these data, interrater reliability was assessed by calculating Cohen's κ, which indicated greater than substantial agreement between our raters (κ = 0.86). Following coding and assessment of reliability, extended, categoric, semantic, and repetition responses were collapsed into one "nonspecific" response category. Raw data for the generation task, indicating the average number of responses generated per cue in each AMI coding category, are reported in Table E2 (ESM 1).

Elaboration Task

The transcribed descriptions were scored according to the Autobiographical Interview (AI) scoring procedure (Levine et al., 2002), which involves segmenting the descriptions into distinct units of information (often a grammatical clause) that independently convey information. Each unit is then coded according to the nature of information it conveys (e.g., occurrence, person, perceptual detail, fact, statement, thought, emotion). Units were then collapsed into two broad categories, internal (episodic) and external (nonepisodic) details. Internal details are those describing specific information pertaining to the main event being recalled (e.g., who was there, perceptual, contextual, and emotional elements) and measure episodic memory processing. External details describe semantic knowledge or general facts (including personal semantics or facts/knowledge about the self), tangential event information (i.e., specific information relating to a different event), or metacognitive statements, and they capture both semantic processing and task adherence. Three blind coders were trained on an independent set of memory descriptions (provided by the developers of the AI) using the procedure laid out in the AI scoring manual. Because of the time-consuming nature of the task, two of the coders scored distinct sets of elaboration descriptions, the third coder rescored a random selection of descriptions (n = 20), which were then used for reliability estimates.

All detail categories were collapsed into "internal" and "external" details, and reliability was assessed by calculating Cohen's κ for these categories across the selected descriptions, which indicated near perfect agreement between raters (κ > 0.90 for both internal and external details). Raw data for the elaboration retrieval task, indicating average number of details generated per cue in each AI coding category, are reported in full in Table E3 (ESM 1).

Analyses

To control for individual differences in verbal fluency (output), which is influenced by factors like mental processing speed and executive functioning, we assessed autobiographical specificity by calculating the proportion of specific-to-total responses and internal-to-total details, which were subsequently used as out primary outcome variables.

These data were analyzed using linear mixed-effects modelling. Compared to the standard ANOVA, which looks at group-level effects, mixed-effects models offer the opportunity to treat global cognitive functioning (MoCA scores) as a continuous variable, which aligns well with our experimental questions. All models were structured as follows:

$$Y_i = \mu Z_i + \beta X_i + \varepsilon_i,$$

where Y_i denotes a vector containing the values of the predictand or dependent variable (autobiographical specificity measures) for the ith participant, μ a vector of q random-effects estimates, Z_i a matrix of q random-effect predictors for the ith participant, β a vector of p fixed-effects beta weight estimates for each predictor included in the model, X_i a matrix of p predictors or independent variables for the ith participant, and ε_i the model fit error, capturing the discrepancy between the prediction made by the model for each observation from the ith participant and the measured value.

Two models were constructed for the generation retrieval task. In the first, the predictor variables were MoCA total score and cue type along with their interaction. In the second, the predictor variables were MoCA Memory score, MoCA Executive Functioning score, MoCA "F" fluency task score, and cue type, along with the two-way interaction between each MoCA scale and cue type. In both models, the predictand was the ratio of specific-to-total memories generated. The MoCA "F" fluency task score was included as a predictor variable to estimate the contribution of strategic search, inhibition, and cognitive control processes. We felt it was important to include estimates of these nonepisodic processes as they are theoretically related to our outcome measure (Alvarez & Emory, 2006), which is more generally akin to an autobiographical fluency task and to task adherence (Ford, Rubin, & Giovanello, 2014). Similarly, two models were constructed for the elaboration retrieval task. In the first, the predictor variables were MoCA total score and cue type along with their interaction. In the second, the predictor variables were MoCA Memory score, MoCA Executive Functioning score, and cue type, along with the two-way interaction between each MoCA scale and cue type. In both models, the predictand was the ratio of internal-to-total details described. Three additional models were constructed to examine the association between global cognitive functioning and the subjective experience of memory recall, as provided by elaboration retrieval task ratings. The fixed effects of the predictors MoCA total score and cue type along with their interaction were modelled. The predictands were vividness, familiarity, and date ratings for each of the three models, respectively. For all mixed model analyses reported, participant and cue type were modelled as random effects predictors to account for idiosyncratic variance due to individual differences in task performance and cue variability, respectively. For all models, the regression coefficients and the p-values used to establish statistical significance were based on Satterthwaite approximations for denominator degrees of freedom, established using the "lme" test performed in jamovi (version 0.9.5.12; The jamovi project, 2019).

Where appropriate, we confirmed our findings at the group level. We split our older adult sample into two clinically distinct samples using the established cutoff score for the MoCA of 26. This cutoff has been shown to have excellent specificity and sensitivity for differentiating between individuals with marginal or impaired cognitive health (e.g., mild cognitive impairment [MCI]) and healthy controls (Nasreddine et al., 2005) and has practical significance since this same cutoff is often applied in clinical settings to screen for individuals with cognitive impairment. Applying this cutoff to our sample of older adults yielded two groups, one characterized by high cognitive performance (n = 26, 13 males; age: M = 69.20, SD = 4.79; education: M = 14.80, SD = 2.81; total MoCA: M = 28.00, SD = 1.22) and a second by low cognitive performance (n = 23, 11 males; age: M = 70.80, SD = 5.23; education: M = 16.10, SD = 4.95; total MoCA: M = 23.40, SD = 2.23). See Table E1 (ESM 1) for a complete reporting of the demographic characteristics and estimates of cognitive functioning for these two groups. We ran separate mixed-design ANOVAs on the ratio of specific-to-total responses and ratio of internal-to-total details, for generation and elaboration retrieval, respectively, with cue type (open-ended vs. closed-ended) as a within-subjects factor and group (high vs. low cognitive performers) as a between-subjects factor. Posthoc comparisons were made, where indicated, using Tukey's HSD. We report effect sizes and their corresponding confidence intervals for all findings. For ANOVA main effects and interaction effects, we report eta square and 90% confidence intervals, and for posthoc comparisons we report Cohen's d and 95% confidence intervals (see Steiger, 2004, for a detailed discussion of this topic). ANOVAs and the corresponding effect sizes were calculated in jamovi (version 0.9.5.12; The jamovi project, 2019). Confidence intervals for eta squared and Cohen's d were calculated using the ci.pvaf and ci.smd functions, respectively, in the MBESS package (version 4.6.0; Kelley, 2019) of R Studio (version 1.1.453; R Core Team, 2018).

Results

Generation Task

A linear mixed model was performed to test the effect of global cognitive functioning and cue type on autobiographical

specificity during generation retrieval. The ratio of specific-to-total generated events was included as the dependent variable with cue type (open-ended or closed-ended), MoCA score, and their interaction as fixed factors in the model. We modelled the random effects of subject and cue. The fixed effect omnibus tests revealed a main effect of MoCA scores ($F_{(1,46.93)}$ = 7.59, p = .008), where older adults with high MoCA scores generated a greater ratio of specific-to-total events than did older adults with low MoCA scores (ß = .02, SE = .007, $t_{(46.93)}$ = 2.75, p = .008; Figure 1). We did find neither a main effect of cue type ($F_{(1,6)}$ = 0.26 p = .63) nor an interaction between these factors ($F_{(1,333.21)}$ = 0.12, p = .73). Variability from the random factors of subject and cue was SD = 0.07 and SD = 0.14, respectively.

To confirm these results, we split our sample into two groups (high vs. low cognitive performers) using the clinically derived cutoff of 26 from the MOCA screener. A mixed-design ANOVA was run on the average ratio of specific-to-total responses generated to each cue with type with group (high vs. low cognitive performers) as a between-subjects factor and cue type (open-ended vs. closed-ended) as a within-subjects factor. Results from this analysis revealed a main effect of cue type (higher level of specificity for open-ended vs. closed-ended; $F_{(1,47)}$ = 4.24, p = .04, η^2 = 0.030, 90% CI [.00; .22]) and group (higher level of specificity for high vs. low cognitive performers; $F_{(1,47)}$ = 8.24, p = .006, η^2 = 0.095, 90% CI [.03; .29]) but did not find a two-way interaction between these terms ($F_{(1,47)}$ = 0.01, p = .918, η^2 = 0.000, 90% CI [.00; .02]).

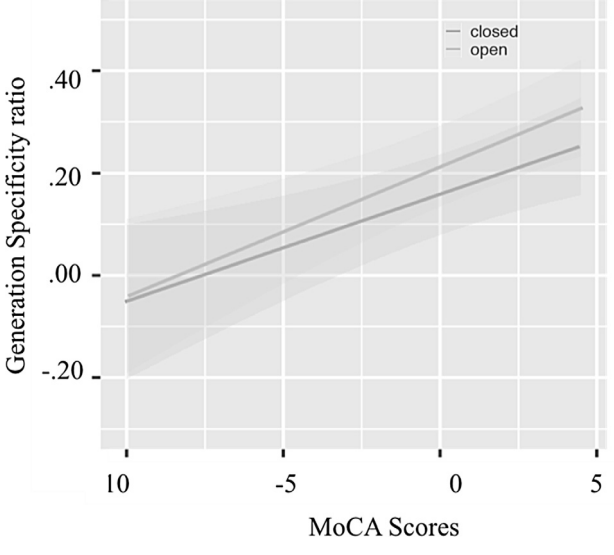

Figure 1. A visualization of the relationship between global cognitive functioning and the specificity of autobiographical memory during the generation retrieval task. The average ratio of specific-to-total events generated by older adult participants to open-ended and closed-ended retrieval cues during 90-s retrieval period is associated with performance on the Montreal Cognitive Assessment (MoCA). MoCA scores are mean-centered and error bands represent standard error of the mean.

A second linear mixed-effects model was performed, as outlined above, but with the ratio of specific-to-total generated events as the dependent variable and with cue type, MoCA Memory, MoCA Executive, and MoCA "F" fluency task scores as fixed factors in the model. The fixed effects omnibus tests revealed a significant main effect of MoCA Memory scores ($F_{(1,43.73)}$ = 7.39, p = .009), viz. older adults with high MoCA Memory scores generated a greater ratio of specific-to-total responses than those with low MoCA Memory scores (ß = .04. SE = .01, $t_{(79.18)}$ = 2.72, p = .009). We did not find significant fixed effects of MoCA Executive score ($F_{(1,84.01)}$ = 3.16, p = .08), cue type ($F_{(1,6)}$ = .26, p = .63), MoCA "F" fluency score ($F_{(1,72.70)}$ = 3.49, p = .07), nor did the interactions between cue type and MoCA Memory score ($F_{(1,343.93)}$ = 0.46, p = .50), cue type and MoCA Executive score ($F_{(1,343.69)}$ = .02, p = .92) or cue type and MoCA "F" fluency score ($F_{(1,337.20)}$ = 0.12, p = .73) result in significant fixed effects. Variability from the random factors of subject and cue was SD = 0.04 and SD = 0.14, respectively.

Elaboration Task

As mentioned above, a linear mixed model was performed to test the effect of global cognitive functioning and cue type on autobiographical specificity during elaboration retrieval. The ratio of internal-to-total details was included as the dependent variable with cue type, MoCA score, and their interaction term included as fixed effects. We also modelled the random intercepts for both cue and subject. The fixed effect omnibus tests failed to find a main effect of MoCA scores ($F_{(1,47.33)}$ = 2.18, p = .15) or cue type ($F_{(1,6)}$ = .75, p = .42), but we did find a significant interaction between MoCA score and cue type ($F_{(1,332)}$ = 4.02, p = .04). Unpacking this interaction, we found that older adults with high MoCA scores described a greater ratio of internal-to-total details than did older adults with low MoCA scores – but only for closed-ended cues (ß = -.007, SE = .004, $t_{(33.62)}$ = -2.01, p = .04). There was no relationship between MoCA score and autobiographical specificity for open-ended cues (Figure 2). Variability from the random factors of subject and cue was SD = 0.11 and SD = 0.013, respectively.

We confirmed these results at a group level by comparing the episodic richness of event elaborations between high and low cognitive performers. To do so, we ran a mixed-design ANOVA on the average ratio of internal-to-total details generated to each cue with group (high vs. low cognitive performers) as a between-subjects factor and cue type (open-ended vs. closed-ended) as a within-subjects factor. We did not find a main effect of cue type ($F_{(1,47)}$ = 0.04, p = .849, η^2 = 0.000, 90% CI [.00; .04]) or group ($F_{(1,47)}$ = 1.99, p = .166, η^2 = 0.032, 90% CI [.00; .16]), but

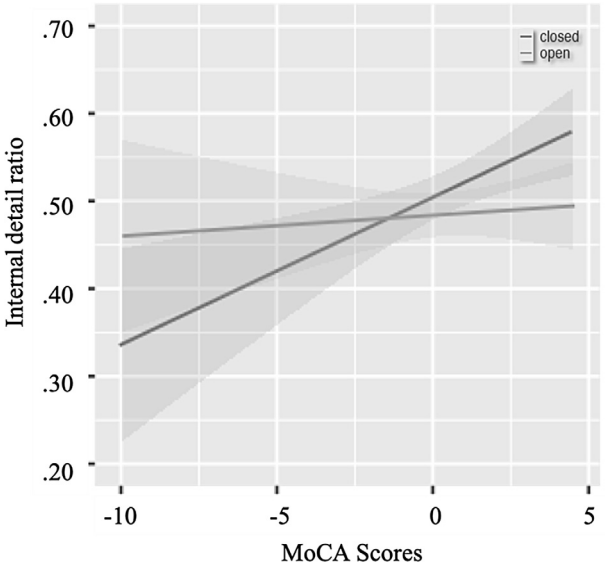

Figure 2. A visualization of the interaction between cue type and global cognitive functioning on the specificity of autobiographical memory during the elaboration retrieval task. The average ratio of internal-to-total details generated by older adult participants during a 3-min retrieval period is associated with performance on the MoCA for closed-ended but not open-ended retrieval cues. MoCA scores are mean-centered and error bands represent standard error of the mean.

we did find a significant interaction between these terms ($F_{(1,47)}$ = 4.23, p = .046, η^2 = 0.088, 90% CI [.00; .22]). Tukey's posthoc comparisons revealed that high cognitive performers generated more episodically rich event elaborations than low cognitive performers for closed-ended cues ($t_{(47)}$ = 3.26, p = .012, Cohen's d = 1.02, 95% CI [-0.54; 0.58]) – but not for open-ended cues, where performance was comparable ($t_{(47)} = 0.17, p = .998$, Cohen's d = 0.072, 95% CI [0.34; 1.52]).

We ran a second linear mixed-effects model with MoCA Memory and Executive subscores as predictors and the ratio of internal-to-total details as the dependent variable (Figure 3). This analysis revealed no main effect of cue type ($F_{(1,6.03)} = .76, p = .42$), MoCA Memory score ($F_{(1,46.12)} = .09$, p = .76), or MoCA Executive score (MoCA Executive, ($F_{(1,46.01)} = 1.73, p = .19$). We also failed to find an interaction between cue type and MoCA Executive scores ($F_{(1,331.25)}$ = $.006, p = .94$). However, we did find a significant interaction effect between cue type and MoCA Memory score ($F_{(1,331.39)}$ = 5.11 p = .02), viz. older adults with high MoCA Memory scores generated a greater ratio of internal-to-total details than those with low MoCA memory scores for events described to closed-ended but not to open-ended retrieval cues (ß = -.02, SE = .007, $t_{(331.39)}$ = -2 .26, p = .02). Variability from the random factors of subject and cue was SD = 0.11 and SD = 0.013, respectively.

Finally, we examined the relationship between the MoCA scores and the subjective ratings of memory elaboration retrieval to determine whether interindividual differences in cognitive functioning relate to the subjective experience of memory recall. We constructed separate models with each of the subjective ratings as the dependent variable (vividness, familiarity, date) and with MoCA score and cue type as predictors. None of these models revealed any association between subjective ratings, main effects of MoCA score, or cue type nor any interaction effects (see Tables 3 and 4).

Discussion

The ability to retrieve specific information about past personal experiences or the specificity of autobiographical memory depends on episodic memory processes (Eichenbaum, Yonelinas, & Ranganath, 2007; Naveh-Benjamin, Hussain, Guez, & Bar-On, 2003; Nyberg et al., 1996; Olsen, Moses, Riggs, & Ryan, 2012; Tulving, 2002). Healthy cognitive status is associated with impairments in episodic memory ability which influence the specificity of autobiographical memory (e.g., Peters et al., 2019). However, age differences in episodic memory are far from homogeneous, and the association between subclinical episodic memory impairments and autobiographical specificity is not yet known. To address this, we asked whether interindividual differences in cognitive functioning in healthy older adults are associated with the ability to engage episodic processes during autobiographical memory retrieval. To this end, we established cognitive functioning in a sample of older adult using the MoCA cognitive assessment tool (Nasreddine et al., 2005) and then measured the specificity of autobiographical memory across two retrieval tasks. The first was an autobiographical fluency task, where participants retrieved multiple specific autobiographical events (generation task), and the second was a memory description task in which participants constructed a detailed account of a single recollected episode (elaboration task). We used established scoring systems to quantify autobiographical retrieval specificity. During the generation task, we calculated the proportion of specific (contextualized) events generated by participants, and during the elaboration task we calculated the proportion of internal (contextual-perceptual) details included in memory descriptions. Prior research showed that episodic memory processes are required to retrieve both specific events and their embedded details from the autobiographical memory knowledge structure (Bryan & Luszcz, 2000; Devitt, Addis, & Schacter, 2017; Holland & Rabbitt, 1990; Levine et al., 2002; Madore, Gaesser, & Schacter, 2014; Piolino et al., 2002, 2006, 2010; Sheldon et al., 2011), making autobiographical specificity a useful metric of episodic memory engagement during retrieval. Within each retrieval task, we examined

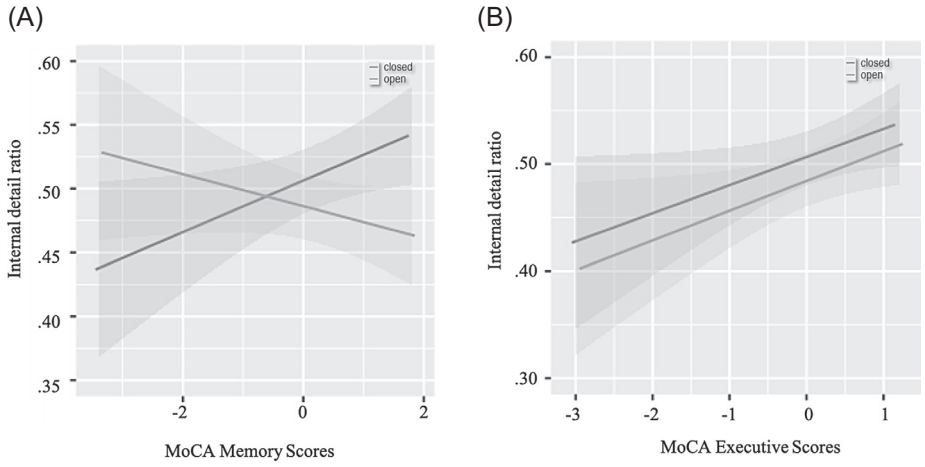

Figure 3. A visualization of the relationship between cognitive domain scores on the MoCA and the specificity of autobiographical memory during the elaboration retrieval task when triggered by open-ended and closed-ended retrieval cues. (A) The average ratio of internal-to-total details generated by older adults during a 3-min retrieval period is associated with performance on the MoCA Memory subscale for closed-ended but not open-ended retrieval. (B) The average ratio of internal-to-total details generated by older adults was not significantly related to MoCA Executive subscale scores nor was there an interaction with cue type. MoCA subscale scores are mean-centered and error bands represent standard error of the mean.

Table 3. The fixed effects from three linear mixed-effects models examining the relationship between global cognitive performance, retrieval cue type and the subjective experience of recollection, as reflected in ratings collected during the elaboration retrieval task

Dependent variable	Fixed effects predictor	*F*	*df*	*p*
Familiarity	MoCA score	0.38	1, 46.6	0.54
	Cue type	0.0604	1, 327.5	0.81
	MoCA score × Cue type	0.4737	1, 327.4	0.49
Vividness	MoCA score	0.20	1, 47.53	0.66
	Cue type	0.75	1, 6.05	0.42
	MoCA score × Cue type	0.87	1, 332.43	0.35
Date	MoCA score	1.37	1, 47.20	0.25
	Cue type	0.16	1,6.00	0.70
	MoCA score × Cue type	2.40	1, 332.52	0.12

Table 4. The random effects due to subject and cue type from three linear mixed-effects models examining the relationship between global cognitive performance, retrieval cue type, and the subjective experience of recollection, as reflected in ratings collected during the elaboration retrieval task

Dependent variable	Random effects predictor	*SD*
Familiarity	Subject	20.00
	Cue type	0.00
Vividness	Subject	1.63
	Cue type	1.52
Date	Subject	0.59
	Cue type	0.43

how episodic memory engagement is modulated by the nature of the cue used to trigger retrieval. Specifically, we asked how the association between cognitive functioning on autobiographical specificity is modulated when retrieval is directed by higher-order semantic information (open-ended cues) or more episodically specific information (closed-ended cues). This manipulation emerged from prior work suggesting that older adults with high cognitive functioning can leverage support from memory cues to more efficiently complete a retrieval task (Craik et al., 1986; Craik & McDowd, 1987; Craik & Schloerscheidt, 2011). Using linear mixed-effects modeling, we examined the relationship between measures of episodic memory engagement (i.e., specific events, internal details) and estimates of cognitive functioning during both generation and elaboration retrieval.

In line with our predictions, interindividual differences in global cognitive functioning was associated with impairments in the specificity of autobiographical memory during both the generation and elaboration retrieval tasks. Importantly, we found that the relationship between cognitive functioning and the specificity of autobiographical memory was driven primarily by interindividual differences in episodic memory functioning (MoCA memory scale) and not by executive functioning (MoCA executive and "F" fluency scales). These data are in line with prior research indicating

that deficits in the specificity of autobiographical memory are amplified in individuals with impaired cognitive functioning, particularly when accompanied by pronounced deficits in episodic memory, such as in older adults diagnosed with Alzheimer's disease or aMCI (Donix et al., 2009; El Haj, Antoine, Nandrino, & Kapogiannis, 2015; Murphy et al., 2008; Seidl, Lueken, Thomann, Geider, & Schröder, 2011; Sheldon et al., 2015). Although none of the participants we tested had received a clinical diagnosis (e.g., Alzheimer's disease or aMCI), our healthy adult sample was characterized by a wide range of cognitive functioning, as established using the MoCA cognitive assessment tool. This particular measure was chosen for its excellent sensitivity and selectivity in distinguishing between healthy and pathological aging trajectories (Nasreddine et al., 2005), and recent findings have linked scores on MoCA memory scale to brain regions implicated in episodic memory processing (Ritter, Hawley, Banks, & Miller, 2017). This suggests that approximately half of our healthy older adult sample presented with subclinical global cognitive and episodic memory deficits, in the absence of dementia, which strongly corresponded to impairments in the specificity of autobiographical memory. Importantly, this relationship was evident across multiple forms of autobiographical memory retrieval, indicating that impairments in cognitive functioning – and episodic memory in particular – manifest throughout this complex cognitive task. This aligns with prior work demonstrating that episodic memory processes are required to associate autobiographical knowledge together during both generation and elaboration forms of retrieval (Peters et al., 2019).

However, upon examining the association between cognitive functioning and autobiographical specificity in more detail, we found that it differed between the two tested forms of autobiographical retrieval, and this difference was driven by the nature of the retrieval cue. In the present study, cue type was manipulated to represent different types of autobiographical information, which we postulated would influence how episodic events would be accessed from the autobiographical knowledge structure (Conway, 2005; Conway & Pleydell-Pearce, 2000). Open-ended retrieval cues were designed to represent broader conceptual autobiographical information (e.g., "travelling"), which would lead to the retrieval of generalized or semantic event information that is hypothesized to remain relatively intact in older adults (e.g., Levine et al., 2002). Closed-ended retrieval cues were designed to represent episodically specific information (e.g., actions, contexts), which would lead to the retrieval of event-specific knowledge. Access to such perceptual-contextual knowledge necessarily requires episodic memory processing and, therefore, can potentially discriminate between healthy and unhealthy aging trajectories (e.g., Levine et al., 2002; Tulving, 2002).

While we did not find cue effects during the generation task (addressed below), we did find that cue type influenced the relationship between cognitive functioning and the specificity of autobiographical memory during elaboration retrieval, such that the MoCA score positively predicted the episodic richness of event elaborations for closed-ended, but not for open-ended cues. In other words, when retrieval is triggered by a closed-ended cue, older adults with low cognitive functioning (i.e., low MoCA scores) show a relative impairment in accessing specific episodic details when constructing a detailed event representation. We take this finding as evidence that older adults with high cognitive functioning (i.e., high MoCA scores) were able to leverage the event-specific information represented by the closed-ended cues to improve access to specific autobiographical event details, whereas those with low cognitive functioning could not. This interpretation rests on the classic finding that healthy older adults can benefit from environmental factors, including certain types of retrieval cue, to improve their performance on complex retrieval tasks (Craik et al., 1986; Craik & McDowd, 1987; Craik & Schloerscheidt, 2011). This appears to be especially true for naturalistic autobiographical memory tasks, such as that employed in the present study, which already provide minimal external retrieval support (Craik, 1983). Our results build on literature by demonstrating that, similarly, high cognitive performers can leverage the contextual support represented by closed-ended retrieval cues to maintain or even improve autobiographical specificity. If high and low cognitive performance on the MoCA can be considered an indication of healthy and unhealthy cognitive "status," respectively (Nasreddine et al., 2005), our findings also suggest that, during elaboration retrieval, closed-ended memory cues can distinguish between healthy and unhealthy aging trajectories.

The mechanism by which closed-ended cues improved autobiographical specificity for older adults with high cognitive functioning is open to interpretation, particularly given that dimensions other than "endedness" are reflected in our cue manipulation. For instance, closed-ended cues were more likely to represent specific spatial contexts ("mall"), whereas the open-ended cues were more likely to represent activity themes ("travelling"). Prior research showed that spatial contexts improve autobiographical specificity during elaboration retrieval by providing a supportive scaffold to guide the recollection of episodic details (Robin, 2018; Robin, Wynn, & Moscovitch, 2016; Sheldon & Chu, 2017). Consistent with our own findings, healthy older adults benefit from spatial cues during autobiographical retrieval (Robin & Moscovitch, 2017), whereas populations with global cognitive impairment, such as aMCI and Alzheimer's disease patients, have difficulty constructing a strong spatial scaffold to support retrieval specificity (Serino,

Morganti, Di Stefano, & Riva, 2015; Serino & Riva, 2014). Closed-ended cues could also represent more familiar event information, which high-functioning older adults can use to access more rehearsed, and thus more detailed, memories than low-functioning older adults. Another possibility is that the cues also differed in emotional valence, such that the open-ended cues are more positive ("celebrating") than the close-ended cues, which tend to be more neutral ("offices"). However, based on findings that healthy but not unhealthy cognitive status is associated with a strong positivity bias (Döhnel et al., 2008; Mather & Carstensen, 2005), we would expect higher MoCA scores to be associated with improved performance to open-ended cues compared to closed-ended cues, which was not the case. Finally, it is plausible that high cognitive performers are able to flexibly recruit additional neurocognitive processes, including those supported by the prefrontal cortex, such as cognitive control, to support elaboration retrieval in closed-ended retrieval scenarios (Cabeza, 2002; Duarte, Ranganath, Trujillo, & Knight, 2006; Lighthall et al., 2014). Because we did not collect comprehensive neuropsychological data in the current sample, it is difficult to confidently speak to compensatory recruitment, although in the present study estimates of executive functioning were not associated with autobiographical specificity, which argues against this interpretation.

As noted above, cue type did not modulate the association between cognitive functioning and the specificity of autobiographical memory during the generation retrieval task. Instead we found that, across cue type, high cognitive performers tended to generate a greater proportion of specific events compared to low cognitive performers, and that this relationship was driven primarily by episodic memory ability (MoCA memory subscale). This suggests that, counter to our predictions, both open-ended and closed-ended cues may recruit episodic memory to the same extent when generating specific events. This is likely because episodic processes critically support the formation of associations between disparate autobiographical event representations (Eichenbaum, 2003, 2004), which is critical to generation retrieval irrespective of how it is triggered. This fits with previous research demonstrating that episodic processes are recruited whenever one must associate autobiographical information in mind, regardless of whether at the level of event or detail (see Peters et al., 2019, for a detailed discussion on this topic). However, some have suggested that these forms of autobiographical specificity instead depend on separable processes (Dritschel et al., 1992; Kyung et al., 2016; Martinelli et al., 2013; Rathbone, Holmes, Murphy, & Ellis, 2015; Roberts et al., 2018). For example, generation retrieval is akin to an autobiographical memory fluency task, which some propose is more dependent on executive processes than elaboration retrieval (Martinelli et al., 2013; Piolino et al., 2010; Roberts et al., 2018). As such, it could be that low cognitive functioning in older adults primarily reflects an executive processing deficit, which would influence performance on a fluency task, regardless of how retrieval was cued. However, in the present study, autobiographical specificity during generation retrieval was not related to either the MoCA executive subscale or, somewhat surprisingly, to performance on the MoCA "F" fluency task, which suggests that indiscriminate executive deficits are, perhaps, not the best explanation for these findings. To more confidently tease apart executive function contributions to autobiographical specificity, future studies could replicate the reported experiment yet include a more in-depth neuropsychological test battery (see Piolino et al., 2010, for related findings).

Interestingly, when examining the average number of specific and nonspecific responses generated to each cue (see ESM 1, Table E2), we found that both high and low performing older adults retrieve more specific events to open-ended compared to closed-ended cues. This suggests that open-ended cues direct a more effective, "top-down" search strategy as guided by the broader conceptual information represented in the cues This strategy may take advantage of the organizational structure of autobiographical memory and broader conceptual links between events (in that specific information can be accessed via the broader concepts in which it is embedded). By comparison, closed-ended cues appear to direct a less effective, "bottom-up" search strategy as guided by event-specific information resulting in the retrieval of fewer specific events. This suggests that event knowledge is not organized according to the more "ad-hoc" associations represented by closed-ended cues (contexts or actions), making it more difficult to access multiple related specific events.

Limitations and Alternate Interpretations

As with many studies, there are some methodological limitations worth noting. First, despite basing our sample size on prior work exploring interindividual (e.g., Baudouin et al., 2006; Craik et al., 2018) and group differences (e.g, D'Angelo et al., 2016) in autobiographical memory and other complex forms of cognition, the number of participants tested is relatively small for a study of this nature. While most of our results were associated with large effect sizes, our small sample size raises questions about the statistical power of our findings particularly with respect to cue effects during generation retrieval. To this end, we are encouraged to replicate our findings in future work. Another methodological limitation discussed at some length relates to the characterization of the open-ended and closed-ended cues, which framed how we interpreted

the association between cognitive functioning and autobiographical specificity, particularly in the context of elaboration retrieval. It certainly could be the case that these cues differ on dimensions other than "endedness" (e.g., spatial contexts vs. event-themes or neutral vs. positive emotion), and it will be important for future research to further refine which dimension represents the "active ingredient." Nonetheless, we demonstrate that some cues, particularly those representing event-specific information (including spatial contexts), are better at distinguishing between healthy and unhealthy aging trajectories and their association with the specificity of autobiographical memory. Several additional factors cannot be completely ruled out using the methodology employed in the present study. It is possible that older adults with low cognitive functioning simply had more difficulty understanding and complying with task instructions, or that their performance was influenced by more global changes in processing speed, particularly for the generation task. Indeed, explicitly instructing individuals to retrieve many "specific" events within a restricted time period requires one to maintain task goals online, inhibit irrelevant or inappropriate responses and engage in strategic search processes, as well as to rapidly retrieve information, all of which tend to be impaired in older adults (Ford et al., 2014). Therefore, it is possible that results from the generation task suggest that high-functioning older adults are simply better able to understand and adhere to task instructions than low-functioning older adults. If this was the case, we might expect that measures of executive functioning, particularly phonemic "F" fluency, which taps into cognitive processes thought to be important for task adherence as well as speed of retrieval, would be associated with interindividual differences in autobiographical specificity during generation retrieval. This was not the case in the present study, where "F" fluency performance did not relate to the specificity of autobiographical memory during generation (or elaboration). Nonetheless, possible differences in task adherence and processing speed should be considered when interpreting our results. Finally, it is possible that low cognitive performing older adults were simply less engaged with their community or had major lifestyle differences, which could influence both global cognitive functioning and/or the availability of autobiographical events at retrieval. While this is certainly a possibility, all recruited participants responded to advertisements posted in the community, suggesting they are, at least somewhat, active and were confirmed to life independently, which implies minimal functional impairments across our older adult sample. In addition, both high and low cognitive performers disproportionately retrieved remote events (i.e., those experienced over 10 years ago), which argues against the notion that lifestyle differences as a function of recent cognitive changes is influencing the availability of prior events. Nonetheless, longstanding lifestyle differences and subtle differences in functioning impairment were not formally assessed, making it difficult to rule them out as possible contributing factors.

Conclusion

The reported results indicate that subtle subclinical memory deficits in older adults, as measured with a simple cognitive screening test, are linked to episodic memory impairments during two forms of autobiographical memory retrieval, when retrieving multiple specific past events or recalling the specific details of a single experience. More generally, our results speak to how interindividual differences in cognitive status can influence the ability to access autobiographical information. Since autobiographical memory processes critically support several nonmnemonic tasks important for effective daily functioning (Bluck, 2003; Pillemer, 2003; Prebble, Addis, & Tippett, 2013), our results suggest that individual differences in normal aging can alter several facets of daily life (e.g., problem-solving, self-concept or identity). Our results mirror patterns observed when comparing healthy older adults to those with aMCI, a pathological syndrome that targets episodic memory (Donix et al., 2009; Murphy et al., 2008; Sheldon et al., 2015). This parallel raises the possibility that autobiographical memory deficits could represent a useful pre-clinical marker of an unhealthy aging trajectory.

Electronic Supplementary Material

The electronic supplementary material is available with the online version of the article at https://doi.org/10.1024/1662-9647/a000219

ESM 1. The electronic supplemental materials section contains additional data providing the reader with a more detailed characterization of our tested sample of older adults, including a breakdown according to cognitive status to supplement group-level comparisons made in the manuscript. We also include scoring data for both the generation and elaboration retrieval tasks broken down by sub-category to allow readers to more carefully evaluate our scored data.

References

Addis, D., Roberts, R., & Schacter, D. (2011). Age-related neural changes in autobiographical remembering and imagining. *Neuropsychologia, 49*, 3656–3669.

Addis, D., & Tippett, L. (2004). Memory of myself: Autobiographical memory and identity in Alzheimer's disease. *Memory, 12*, 56–74.

Aizpurua, A., & Koutstaal, W. (2015). A matter of focus: Detailed memory in the intentional autobiographical recall of older and younger adults. *Consciousness and Cognition, 33*, 145–155.

Alvarez, J. A., & Emory, E. (2006). Executive function and the frontal lobes: A meta-analytic review. *Neuropsychology Review, 16*, 17–42.

Barnabe, A., Whitehead, V., Pilon, R., Arsenault-Lapierre, G., & Chertkow, H. (2012). Autobiographical memory in mild cognitive impairment and Alzheimer's disease: A comparison between the Levine and Kopelman interview methodologies. *Hippocampus, 22*, 1809–1825.

Baudouin, A., Vanneste, S., Isingrini, M., & Pouthas, V. (2006). Differential involvement of internal clock and working memory in the production and reproduction of duration: A study on older adults. *Acta Psychologica, 121*, 285–296.

Bluck, S. (2003). Autobiographical memory: Exploring its functions in everyday life. *Memory, 11*, 113–123.

Bryan, J., & Luszcz, M. A. (2000). Measurement of executive function: Considerations for detecting adult age differences. *Journal of Clinical and Experimental Neuropsychology, 22*, 40–55.

Cabeza, R. (2002). Hemispheric asymmetry reduction in older adults: The HAROLD model. *Psychology and Aging, 17*, 85–100.

Cabeza, R., Albert, M., Belleville, S., Craik, F. I., Duarte, A., Grady, C. L., ... Reuter-Lorenz, P. A. (2018). Maintenance, reserve and compensation: The cognitive neuroscience of healthy ageing. *Nature Reviews Neuroscience, 19*, 701–710.

Conway, M. A. (2005). Memory and the self. *Journal of Memory and Language, 53*, 594–628.

Conway, M. A., & Pleydell-Pearce, C. W. (2000). The construction of autobiographical memories in the self-memory system. *Psychological Review, 107*, 261–288.

Craik, F. I. M. (1983). On the transfer of information from temporary to permanent memory. *Philosophical Transactions of the Royal Society of London. B, Biological Sciences, 302*(1110), 341–359.

Craik, F. I. M., & Byrd, M. (1982). Aging and cognitive deficits: The role of attentional resources. In F. I. M. Craik & S. E. Trehub (Eds.), *Aging and cognitive processes* (pp. 191–211). New York, NY: Plenum Press.

Craik, F., Eftekhari, E., Bialystok, E., & Anderson, N. D. (2018). Individual differences in executive functions and retrieval efficacy in older adults. *Psychology and Aging, 33*, 1105–1114.

Craik, F., Klix, F., & Hagendorf, H. (1986). *A functional account of age differences in memory*. New York, NY: Routledge.

Craik, F., & McDowd, J. (1987). Age differences in recall and recognition. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 13*, 474–479.

Craik, F., & Schloerscheidt, A. (2011). Age-related differences in recognition memory: Effects of materials and context change. *Psychology and Aging, 26*, 671–677.

D'Angelo, M. C., Smith, V. M., Kacollja, A., Zhang, F., Binns, M. A., Barense, M. D., & Ryan, J. D. (2016). The effectiveness of unitization in mitigating age-related relational learning impairments depends on existing cognitive status. *Aging, Neuropsychology, and Cognition, 23*, 667–690.

Dando, C. J. (2013). Drawing to remember: External support of older adults' eyewitness performance. *PLoS One, 8*(7), e69937.

Dennis, N. A., Bowman, C. R., & Peterson, K. M. (2014). Age-related differences in the neural correlates mediating false recollection. *Neurobiology of Aging, 35*, 395–407.

Devitt, A. L., Addis, D. R., & Schacter, D. L. (2017). Episodic and semantic content of memory and imagination: A multilevel analysis. *Memory & Cognition, 45*, 1–17.

Döhnel, K., Sommer, M., Ibach, B., Rothmayr, C., Meinhardt, J., & Hajak, G. (2008). Neural correlates of emotional working memory in patients with mild cognitive impairment. *Neuropsychologia, 46*, 37–48.

Donix, M., Brons, C., Jurjanz, L., Poettrich, K., Winiecki, P., & Holthoff, V. A. (2009). Overgenerality of autobiographical memory in people with amnestic mild cognitive impairment and early Alzheimer's disease. *Archives of Clinical Neuropsychology, 25*, 22–27.

Dritschel, B. H., Williams, J. M., Baddeley, A. D., & Nimmo-Smith, I. (1992). Autobiographical fluency: A method for the study of personal memory. *Memory & Cognition, 20*, 133–140.

Duarte, A., Ranganath, C., Trujillo, C., & Knight, R. T. (2006). Intact recollection memory in high-performing older adults: ERP and behavioral evidence. *Journal of Cognitive Neuroscience, 18*, 33–47.

Eichenbaum, H. (2003). How does the hippocampus contribute to memory? *Trends in Cognitive Sciences, 7*, 427–429.

Eichenbaum, H. (2004). Hippocampus: cognitive processes and neural representations that underlie declarative memory. *Neuron, 44*, 109–120.

Eichenbaum, H., Yonelinas, A. P., & Ranganath, C. (2007). The medial temporal lobe and recognition memory. *Annual Review of Neuroscience, 30*, 123–152.

El Haj, M., Antoine, P., Nandrino, J. L., & Kapogiannis, D. (2015). Autobiographical memory decline in Alzheimer's disease: A theoretical and clinical overview. *Ageing Research Reviews, 23*, 183–192.

Ford, J. H., Rubin, D. C., & Giovanello, K. S. (2014). Effects of task instruction on the specificity of autobiographical memory in young and older adults. *Memory, 22*, 722–736.

Glisky, E. L. (2007). Changes in cognitive function. In D. R. Riddle (Ed.), *Human aging in brain aging: Models, methods and mechanisms* (pp. 3–20). Boca Raton, FL: CRC Press, Taylor & Francis Group.

Holland, C., & Rabbitt, P. (1990). Autobiographical and text recall in the elderly: An investigation of a processing resource deficit. *The Quarterly Journal of Experimental Psychology, 42*, 441–470.

The jamovi project. (2019). *jamovi [Computer Software]*. Retrieved from https://www.jamovi.org

Kelley, K. (2019). *MBESS: The MBESS R Package*. R package version 4.6.0. https://CRAN.R-project.org/package=MBESS

Kyung, Y., Yanes-Lukin, P., & Roberts, J. E. (2016). Specificity and detail in autobiographical memory: Same or different constructs? *Memory, 24*, 272–284.

Levine, B., Svoboda, E., Hay, J. F., Winocur, G., & Moscovitch, M. (2002). Aging and autobiographical memory: Dissociating episodic from semantic retrieval. *Psychology and Aging, 17*, 677–689.

Leyhe, T., Müller, S., Milian, M., Eschweiler, G. W., & Saur, R. (2009). Impairment of episodic and semantic autobiographical memory in patients with mild cognitive impairment and early Alzheimer's disease. *Neuropsychologia, 47*, 2464–2469.

Lighthall, N. R., Huettel, S. A., & Cabeza, R. (2014). Functional compensation in the ventromedial prefrontal cortex improves memory-dependent decisions in older adults. *Journal of Neuroscience, 34*, 15648–15657.

Madore, K. P., Gaesser, B., & Schacter, D. L. (2014). Constructive episodic simulation: Dissociable effects of a specificity induction on remembering, imagining, and describing in young and older adults. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 40*, 609–622.

Martinelli, P., Sperduti, M., Devauchelle, A.-D., Kalenzaga, S., Gallarda, T., Lion, S., ... Meder, J. F. (2013). Age-related changes in the functional network underlying specific and general autobiographical memory retrieval: A pivotal role for the anterior cingulate cortex. *PloS One, 8*(12), e82385.

Mason, C. F., & Ganzler, H. (1964). Adult norms for the Shipley Institute of Living Scale and Hooper Visual Organization Test based on age and education. *Journal of Gerontology, 19*, 419–424.
Mather, M., & Carstensen, L. L. (2005). Aging and motivated cognition: The positivity effect in attention and memory. *Trends in Cognitive Sciences, 9*, 496–502.
Matuszewski, V., Piolino, P., Belliard, S., de la Sayette, V., Laisney, M., C., Lalevee., & Desgranges, B. (2009). Patterns of autobiographical memory impairment according to disease severity in semantic dementia. *Cortex, 45*, 456–472.
McIntyre, J. S., & Craik, F. I. (1987). Age differences in memory for item and source information. *Canadian Journal of Psychology/ Revue Canadienne de Psychologie, 41*, 175–192.
Murphy, K. J., Troyer, A. K., Levine, B., & Moscovitch, M. (2008). Episodic, but not semantic, autobiographical memory is reduced in amnestic mild cognitive impairment. *Neuropsychologia, 46*, 3116–3123.
Nasreddine, Z. S., Phillips, N. A., Bédirian, V., Charbonneau, S., Whitehead, V., Collin, I., … Chertkow, H. (2005). The Montreal Cognitive Assessment, MoCA: A brief screening tool for mild cognitive impairment. *Journal of the American Geriatrics Society, 53*, 695–699.
Naveh-Benjamin, M., Hussain, Z., Guez, J., & Bar-On, M. (2003). Adult age differences in episodic memory: Further support for an associative-deficit hypothesis. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 29*, 826–837.
Nyberg, L., Bäckman, L., Erngrund, K., Olofsson, U., & Nilsson, L.-G. (1996). Age differences in episodic memory, semantic memory, and priming: Relationships to demographic, intellectual, and biological factors. *The Journals of Gerontology Series B: Psychological Sciences and Social Sciences, 51*, P234–P240.
Nyberg, L., Maitland, S. B., Rönnlund, M., Bäckman, L., Dixon, R. A., Wahlin, Å., & Nilsson, L.-G. (2003). Selective adult age differences in an age-invariant multifactor model of declarative memory. *Psychology and Aging, 18*, 149–160.
Olsen, R., Moses, S., Riggs, L., & Ryan, J. (2012). The hippocampus supports multiple cognitive processes through relational binding and comparison. *Frontiers in Human Neuroscience, 6*(146), 1–13.
Peters, S. L., Fan, C. L., & Sheldon, S. (2019). Episodic memory contributions to autobiographical memory and open-ended problem-solving specificity in younger and older adults. *Memory & Cognition, 47*, 1–14.
Pillemer, D. (2003). Directive functions of autobiographical memory: The guiding power of the specific episode. *Memory, 11*, 193–202.
Piolino, P., Coste, C., Martinelli, P., Macé, A.-L., Quinette, P., Guillery-Girard, B., & Belleville, S. (2010). Reduced specificity of autobiographical memory and aging: Do the executive and feature binding functions of working memory have a role? *Neuropsychologia, 48*, 429–440.
Piolino, P., Desgranges, B., Benali, K., & Eustache, F. (2002). Episodic and semantic remote autobiographical memory in ageing. *Memory, 10*, 239–257.
Piolino, P., Desgranges, B., Clarys, D., Guillery-Girard, B., Taconnat, L., Isingrini, M., & Eustache, F. (2006). Autobiographical memory, autonoetic consciousness, and self-perspective in aging. *Psychology and Aging, 21*, 510–525.
Prebble, S. C., Addis, D. R., & Tippett, L. J. (2013). Autobiographical memory and sense of self. *Psychological Bulletin, 139*, 815–840.
R Core Team. (2013). *R: A language and environment for statistical computing*. Vienna, Austria: R Foundation for Statistical Computing. http://www.R-project.org
Rathbone, C. J., Holmes, E. A., Murphy, S. E., & Ellis, J. A. (2015). Autobiographical memory and well-being in aging: The central role of semantic self-images. *Consciousness and Cognition, 33*, 422–431.
Ritter, A., Hawley, N., Banks, S. J., & Miller, J. B. (2017). The association between montreal cognitive assessment memory scores and hippocampal volume in a neurodegenerative disease sample. *Journal of Alzheimer's Disease, 58*, 695–699.
Roberts, J. E., Yanes-Lukin, P., & Kyung, Y. (2018). Distinctions between the specificity of autobiographical memory and detail: Trajectories across cue presentations. *Consciousness and Cognition, 65*, 342–351.
Robin, J. (2018). Spatial scaffold effects in event memory and imagination. *Wiley Interdisciplinary Reviews: Cognitive Science, 9*, e1462.
Robin, J., & Moscovitch, M. (2017). Familiar real-world spatial cues provide memory benefits in older and younger adults. *Psychology and Aging, 32*, 210–219.
Robin, J., Wynn, J., & Moscovitch, M. (2016). The spatial scaffold: The effects of spatial context on memory for events. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 42*, 308–315.
Schear, J. M., & Harrison, W. R. (1988). Estimating WAIS IQ from the Shipley institute of living scale: A replication. *Journal of Clinical Psychology, 44*, 68–71.
Seidl, U., Lueken, U., Thomann, P. A., Geider, J., & Schröder, J. (2011). Autobiographical memory deficits in Alzheimer's disease. *Journal of Alzheimer's Disease, 27*, 567–574.
Serino, S., Morganti, F., Di Stefano, F., & Riva, G. (2015). Detecting early egocentric and allocentric impairments deficits in Alzheimer's disease: An experimental study with virtual reality. *Frontiers in Aging Neuroscience, 7*, 88.
Serino, S., & Riva, G. (2014). What is the role of spatial processing in the decline of episodic memory in Alzheimer's disease? The "mental frame syncing" hypothesis. *Frontiers in Aging Neuroscience, 6*, 33.
Sheldon, S., & Chu, S. (2017). What versus where: Investigating how autobiographical memory retrieval differs when accessed with thematic versus spatial information. *The Quarterly Journal of Experimental Psychology, 70*, 1909–1921.
Sheldon, S., McAndrews, M., & Moscovitch, M. (2011). Episodic memory processes mediated by the medial temporal lobes contribute to open-ended problem solving. *Neuropsychologia, 49*, 2439–2447.
Sheldon, S., McAndrews, M., Pruessner, J., & Moscovitch, M. (2016). Dissociating patterns of anterior and posterior hippocampal activity and connectivity during distinct forms of category fluency. *Neuropsychologia, 90*, 148–158.
Sheldon, S., & Moscovitch, M. (2012). The nature and time-course of medial temporal lobe contributions to semantic retrieval: An fMRI study on verbal fluency. *Hippocampus, 22*, 1451–1466.
Sheldon, S., Vandermorris, S., Al-Haj, M., Cohen, S., Winocur, G., & Moscovitch, M. (2015). Ill-defined problem solving in amnestic mild cognitive impairment: Linking episodic memory to effective solution generation. *Neuropsychologia, 68*, 168–175.
Spencer, W. D., & Raz, N. (1995). Differential effects of aging on memory for content and context: A meta-analysis. *Psychology and Aging, 10*, 527–539.
Steiger, J. H. (2004). Beyond the F test: effect size confidence intervals and tests of close fit in the analysis of variance and contrast analysis. *Psychological Methods, 9*, 164–182.
Tulving, E. (2002). Episodic memory: from mind to brain. *Annual Review of Psychology, 53*, 1–25.
Van Petten, C. (2004). Relationship between hippocampal volume and memory ability in healthy individuals across the lifespan: Review and meta-analysis. *Neuropsychologia, 42*, 1394–1413.

Van Petten, C., Plante, E., Davidson, P. S., Kuo, T. Y., Bajuscak, L., & Glisky, E. L. (2004). Memory and executive function in older adults: Relationships with temporal and prefrontal gray matter volumes and white matter hyperintensities. *Neuropsychologia, 42*, 1313–1335.

Verhaeghen, P., Marcoen, A., & Goossens, L. (1992). Improving memory performance in the aged through mnemonic training: A meta-analytic study. *Psychology and Aging, 7*, 242–251.

Williams, J. M., & Broadbent, K. (1986). Autobiographical memory in suicide attempters. *Journal of Abnormal Psychology, 95*, 144–149.

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