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Episodic simulation of past and future events in older adults: Evidence from an experimental recombination task

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Abstract

We recently reported that older adults generate fewer episodic details than younger adults when remembering past events and simulating future events. We suggested that the simulation findings reveal an age deficit in recombining episodic details into novel events, but they could also result from older adults 'recasting' entire past events as future events. In this study, we used an experimental recombination paradigm to prevent 'recasting' while imagining, and to compare imagining the future with imagining the past. Older adults generated fewer episodic details for imagined and recalled events than younger adults, thereby extending the age-related simulation deficit to conditions of recombination.

Keywords

episodic memory; aging; future simulation; imagining

Recent cognitive, neuropsychological, and neuroimaging studies have revealed striking commonalities in the processes that support remembering the past and imagining the future (for reviews, see Buckner & Carroll, 2007; Hassabis & Maguire, 2007; Schacter, Addis, & Buckner, 2007; Schacter, Addis, & Buckner, 2008; Szpunar, in press). For example, cognitive studies indicate that manipulating factors such as valence and temporal distance from the present (e.g., D'Argembeau & van der Linden, 2004) and contextual vividness (Szpunar & McDermott, 2008), and individuals differences in visual imagery abilities and emotion regulation strategies (D'Argembeau & van der Linden, 2006), exert similar effects on the phenomenology of past and future events. Neuropsychological evidence reveals that amnesic patients exhibit deficits in imagining future or novel events (Hassabis, Kumaran, Vann, & Maguire, 2007; Klein, Loftus, & Kihlstrom, 2002; Tulving, 1985), as do patients with mild Alzheimer's disease (Addis, Sacchetti, Ally, Budson, & Schacter, in press). Neuroimaging studies show that many of the same brain regions that are active when remembering the past are similarly active when imagining the future (Addis, Pan, Vu, Laiser, & Schacter, 2009; Addis, Wong, & Schacter, 2007; Botzung, Dankova, & Manning, 2008; Hassabis, Kumaran, & Maguire, 2007; Okuda et al., 2003; Szpunar, Watson, & McDermott, 2007). These and

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related observations have led us to propose the constructive episodic simulation hypothesis (Schacter & Addis, 2007, 2009), which holds that 1) past and future events draw on similar information and rely on similar underlying processes; 2) episodic memory supports the construction of future events by extracting and recombining stored information into a simulation of a novel event, and 3) a critical function of a constructive memory system is to make information available for simulation of future events, thereby enabling past information to be used flexibly in simulating alternative future scenarios, but also resulting in vulnerability to memory errors, such as source misattribution and false recognition. Other related theories, such as the scene construction hypothesis (Hassabis & Maguire, 2007) also emphasize the importance of retrieving relevant pieces of information from memory and integrating these ‘information components’ into a coherent scenarios. Indeed, Hassabis, Kumaran, Vann and Maguire (2007) demonstrated that hippocampal amnesic patients exhibit deficits in imagining coherent scenes.

We recently tested aspects of the constructive episodic simulation hypothesis in a study of cognitive aging (Addis, Wong, & Schacter, 2008). Specifically, we examined whether previous findings showing that the episodic specificity of autobiographical memories declines with age (Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002) extend to simulated future events. These earlier findings were generated by a procedure known as the Autobiographical Interview (AI), in which young and older participants recalled past personal events in response to probes. Transcriptions were segmented into distinct details that were classified as either internal (episodic) or external (semantic). Internal details involve the “core” of the retrieved episode, including who, what, where, and when. External details involve related facts, elaborations, or references to other events. When remembering past events, older adults generated fewer internal and more external details than younger adults (Levine et al., 2002). Based on the constructive episodic simulation hypothesis, we predicted that age-related changes for past events would extend to future events. Using an adapted version of the AI (Addis et al., 2008), we found that older adults produced fewer internal and more external details than young adults for both remembered past events and imagined future events. Past and future scores were positively correlated with each other for internal and external details, whereas internal and external detail scores were uncorrelated with one another.

These results provide initial insights into the relation between remembering the past and imagining the future in older adults (see also Spreng & Levine, 2006), and support the constructive episodic simulation hypothesis and related theories. However, they leave open at least two important questions. First, though we argued that the age deficits in imagining future events reflect a problem related to retrieving details from prior episodes and recombining them into a novel imaginary scenario, the observed similarities between remembering the past and imagining the future might instead occur because younger and older adults simply “recast” entire memories of past events into the future. For example, when asked to imagine a future event involving a “chair”, a participant might remember an incident that occurred last week and imagine the episode occurring again next week; the adapted AI paradigm used in our initial study did not control whether subjects recombined or recast past events. Second, it is unclear whether the age-related deficit documented for imagining future events reflects a more general deficit in imagining or simulating any detailed episodic event, regardless of temporal direction.

To address these issues, we use here an experimental recombination paradigm that we developed initially for a neuroimaging study of young adults (Addis et al., 2009). In this paradigm, participants first provide a set of autobiographical memories, each comprised of a person, place, and object. They later return for a separate session in which they are cued to recall some of these episodes in as much detail as possible. For the imagination trials, details concerning person, place, and object are experimentally recombined across events and participants are asked either to imagine an event that might occur in the future, or might have occurred in the past, involving the recombined person, place, and object. The fMRI data from this experimental recombination procedure study revealed activation of the same core network of regions documented in our earlier study of remembering the past and imagining the future; moreover, the same pattern of increased activity for imagining was evident for both the imagined future and the imagined past (Addis et al., 2009).

According to the constructive episodic simulation hypothesis, even under conditions of experimental recombination that preclude recasting events, older adults should exhibit reduced internal and increased external details for imagined events that parallel the findings for remembered events. Further, since the constructive episodic simulation hypothesis holds that the process of recombining event details thought to be affected by aging is required for both imagined future and imagined past events, comparable age differences should be observed for both imagined future and imagined past events. Moreover, although some internal details (person, place and object) are provided as cues in the recombining paradigm, it is possible that in the events simulated by older adults the details are not integrated as cohesively relative to the events of younger adults. We evaluate each of these predictions in the present experiment.

Methods

Participants

Twenty-five young and twenty-five older adults with no history of neurological or psychiatric impairment gave informed written consent in a manner approved by the Harvard Institutional Review Board. All older adults had a mini-mental state examination score of 27 or higher, excluding dementia. Seven young and seven older adults were excluded due to technical difficulties, speech problems, or non-fluent English. Thus, data from 18 young (9 males; mean age, 21.89 years, SD=3.61) and 18 older adults (7 males; mean age, 74.89, SD=5.56) are presented. Older adults had completed significantly more years of education than younger adults (Older: M=16.39 years, SD=2.62; Younger: M=14.56, SD=2.09; p = .026).

Stimuli Collection

This study employed an experimental recombination paradigm (Addis et al., 2009) that required participants to retrieve memories of 35 events in an initial session. All events had to be from the past five years, and specific in time and place (i.e., lasting no longer than one day). Participants were provided with an extensive list of event cues to facilitate retrieval, but memories were not limited to these cues. Participants devised a brief ‘title’ for each event and specified three details from each memory: a person (other than themselves), an object featuring in the memory, and the location at which the event occurred. Trial-stimulus-sets for the AI session were created using these data. Each stimulus-set contained a person, place and object event detail, and the corresponding title of the memory from which this detail was gleaned. For the past-recall trials, each stimulus set comprised the person, place and object from one event (4 trials). For past- and future-imagine trials, stimulus sets comprised person, place and object details taken (a) all from the same event (4 trials for each imagine condition); or randomly taken from either (b) two events (4 trials each) or (c) from three events (4 trials each). This *recombination load* manipulation was included to enable examination of possible effects of the number of memories drawn upon in a simulation.

AI Session

Participants completed an adapted version of the AI (Levine et al., 2002) one to three weeks after the first session (M = 8.55 days, SD= 3.07). Trials were blocked according to condition, to reduce cognitive load and facilitate older adults’ understanding of the instructions for each condition. The order of presentation of conditions was counterbalanced across subjects. For each trial, participants were shown a cueing slide on a monitor and were instructed to recall or imagine an event and to generate as much detail about that event as possible within a 3-minute time limit. The first line of the slide indicated the task to be completed (e.g., “imagine future event that involves”). Lines 2–4 contained the trial-stimulus-set with each line containing a detail followed by the corresponding memory title (i.e., “[detail]: [event title]”); within the square brackets, relevant personal event stimuli were inserted. For the future- and past-imagine event trials, participants were asked to imagine a plausible personal experience involving the person, location and object specified on the cueing slide, that might occur in the next five years or have might have occurred (but did not actually occur) in the last five years. It was explained that the corresponding event title was given to provide the context for each detail so the subject would know exactly which person, place or object was being referred to. All imagined events were required to be temporally and contextually specific. For the recall-past task, participants were required to recall as much detail about the experience described by the trial-stimulus-set. General probes were given when needed to clarify instructions and encourage further description of details. After 3 minutes, a bell sounded to indicate the end of the trial.

Participants then dated the event and rated it on a five-point scale for detail (1 = vague with no/few details, 5 = vivid), emotion (i.e., intensity of emotion experienced upon recalling or imagining the event; 1=detachment, 5=highly emotional) and personal significance (i.e., how life-changing the event is; 1=insignificant, 5=life-changing). For imagined events, participants rated the similarity of the imagined event to previously experienced events (1 = the exact event was experienced previously, 5 = the event is completely novel). Note that for two older adults, similarity ratings were not collected successfully. The interview took approximately two hours. Participants were tested individually, and responses were recorded using a digital audio-recorder.

Scoring

The standardized AI scoring procedure (Levine et al., 2002) was used. For each participant, the events from each condition were scored primarily by a trained rater blind to group membership and the hypothesis of this study (3 of 36 interviews were scored by the two interviewers). Each event was scored in the following manner. The central event was first identified; if more than one event was mentioned, the event discussed in most detail that occurred over a brief timeframe was selected as the central event. The transcription was then segmented into distinct details (i.e., chunks of information, e.g., a unique occurrence or thought), and these details were categorized as *internal* (episodic information relating to the central event) or *external* (non-episodic information including semantic details, extended events and repetitions). For each event, the number of internal and external details was tallied, and each total was then averaged across the four events in each condition to create an internal and external AI score for each condition in each participant. All raters scoring the present data also scored a set of 20 imagined future and recalled past events obtained from a previous study (Addis et al., 2008). These scores were subjected to an intraclass correlation analysis, revealing that reliability was high (two-way mixed model; standardized Cronbach’s alpha: internal detail score, .964; external detail score, .905). Additionally, in order to check that the imagined events simulated by young and older adults contained the three presented details, we counted the number of events in which all three details were mentioned. An average of 22 (of 24 imagined events; SD=2.64) included all three details, and there was no significant group difference.

Imagined events were also scored for how cohesively the person, place and object details were integrated into one temporally and contextually specific event (‘event integration’). Even when all three details are included in an ‘event’ that occurs over one day (thus meeting the criteria of episodic), this criterion can be achieved by describing multiple ‘mini-events’ occurring in the same day, but where none of the details actually coincide in the same temporal and/or spatial context. For example, when integrating a Boston friend, a Florida location, and an umbrella, one could imagine (a) being in Miami, walking in the rain with an umbrella and unexpectedly bumping into the Boston friend; or (b) being in Miami walking in the rain with an umbrella, then flying back to Boston and dining with the Boston friend. Thus, we scored how many of the details coincided temporally and contextually in a coherent event (*coinciding details score*; 3 = all three details coincide; 2 = two details coincide in one "mini-event", the other detail features in a separate "mini-event"; 1 = no details coincide). Inter-rater reliability for this scale was high (Kendall's tau-b = .965, $p < .001$) for a subset of 20 imagined past and future events.

Analyses

Subjective ratings were analysed using appropriate non-parametric tests. Note that the series of pairwise Mann Whitney *U* tests were subjected to a Bonferroni-corrected threshold ($p = .001$). AI data were subjected to analyses of variance (ANOVA). Note that for ANOVA, if the assumption of sphericity was violated (as indicated by a Greenhouse–Geisser estimate of sphericity, epsilon, of less than .90), the degrees of freedom were adjusted using Greenhouse–Geisser epsilon (Geisser & Greenhouse, 1958). All ANOVA analyses were followed with Bonferroni-corrected pairwise comparisons.

Results

As noted in the Methods, participants completed the AI session one to three weeks after the initial session in which autobiographical memories were obtained. The delay between sessions differed between the age groups, $t(34)=2.17$, $p = .04$, reflecting a slightly longer delay for young (M=9.61 days, SD=3.53) than older (M=7.50 days, SD=2.15) adults. We believe that this difference is unlikely to have influenced the results of this study for a number of reasons. First, the effect size of this difference is very small, partial $\eta^2 = .12$. Second, it is unlikely that a shorter delay between the first and second session would have resulted in greater impairments in older adults; if anything, it seems more likely that younger adults would be at a disadvantage with the slightly longer delay. Third and most important, if delay is included as a covariate in the two ANOVA analyses of AI data, it is not significant (*p* values > .67).

Phenomenology of autobiographical events

The group means for the phenomenological qualities of recalled and imagined events are shown in Table 1. We examined these phenomenological qualities broken down according to event condition (imagine-future, imagine-past and recall-past) and recombination load condition (i.e., how many past events the person, place and object details were drawn from; one, two or three). To examine whether temporal distance of events differed between conditions or groups, dates of events (converted to days from the present) were analyzed using 3 (Condition) × 2 (Group) mixed factorial ANOVA. Although this analysis revealed a main effect of Condition, $F(2,68) = 3.52$, $p = .04$, bonferroni post-hoc tests indicated that imagined past events were only marginally more distant than imagined future ($p = .06$) and recalled past ($p = .08$) events. Importantly, temporal distance did not differ between groups, $F(1,34) = .24$, $p = .63$, nor was there an interaction of Condition and Group, $F(2,68) = .53$, $p = .59$. Temporal distance was also examined using a 3 (Recombination Load) × 2 (Group) mixed factorial ANOVA. There was no significant effect of Recombination Load, $F(2,68) = 1.06$, $p = .35$, or Group, $F(1,34) = .23$, $p = .64$, and Recombination Load did not interact with Group, $F(2,68) = .16$, $p = .85$. Together, the results of these ANOVA analyses indicate that any group differences on the AI cannot be accounted for by differences in temporal distance.

We also examined whether the rated detail, emotional intensity and personal significance of events differed across group and event condition. Mann-Whitney *U* tests revealed that ratings of emotion for imagined future events and personal significance of imagined past events were

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significantly higher for older relative to younger adults (all p values ≤ .001). No other group differences were evident. Friedman tests indicated there was a main effect of event condition on ratings of detail (p < .001), emotionality (p < .001) and personal significance (p =.006). Post-hoc Wilcoxin Signed Ranks tests revealed that in all cases, this main effect reflected higher ratings for recalled past versus imagined events (all p values < .006). Breaking down these phenomenological data by recombination load indicated that group differences in emotion and personal significance ratings were only evident when the load was 1 (i.e., all details were drawn from the same event; p ≤ .001). When required to recombine details from two or three events, the emotion and personal significance ratings were not significantly higher in older adults. Friedman tests revealed a main effect of load was evident for detail (p = .005), emotionality (p = .013) and personal significance (p = .03). In general, this effect reflected highest ratings when all details were taken from the same event (load 1) and lowest ratings when all details came from different events. Specifically, detail was significantly higher for load 1 versus 2 and 3, and emotion and personal significance ratings were higher for loads 1 and 2 versus 3 (all p values ≤ .04).

Subjects also rated imagined events for similarity to real past experiences on a five-point scale (1 = completely imaginary; 5 = identical to real events). The mean ratings for both groups ranged between 2.16 and 2.79, indicating that while elements of imaginary events may be similar to past events, the imagined events are in no way *identical* to real experiences. The similarity ratings did not differ significantly across the imagined conditions (p = .362), or across groups (all p values > .001). However, a Friedman test indicated there was a main effect of recombination load on similarity ratings (p < .001), and pairwise Wilcoxin tests showed that the similarity to past events was highest when all details were taken from the same event (load of 1) and decreased linearly with increasing recombination (all pairwise tests significant, all p values ≤ .01).

Adapted Autobiographical Interview

To ensure that the length of the two-hour AI session and possible fatigue did not impact upon performance (especially in older adults), we compared internal and external AI scores obtained in the first and second halves of the session. To this end, we conducted a 2 (Session Half: First, Second) × 2 (Detail: Internal, External) × 2 (Group: Young, Older) mixed factorial ANOVA with with repeated factors of Session Half and Detail and between factor of Group. This analysis revealed no main effect of Session Half, $F(1,33)=.01$, $p=.94$. Moreover, Session Half did not interact significantly with Group, $F(1,33)=.41$, $p=.53$, or with Detail, $F(1,33)=1.66$, $p=.21$.

We next conducted a 3 (Condition: Past-Imagine, Future-Imagine, Past-Recall) × 2 (Detail: Internal, External) × 2 (Group: Young, Older) mixed factorial ANOVA with repeated factors of Condition and Detail and between factor of Group (Figure 1A–D). This analysis revealed a main effect of Detail, $F(1,34)=81.66$, $p<.001$, with more internal than external details generated when describing events. The main effect of Group was not significant, $F(1,34)=0.37$, $p<.55$, due to a crossover interaction between Detail and Group, $F(1,34)=22.48$, $p<.001$, where young adults generated more internal details than older adults ($p=.005$), whereas older adults generated more external details than young adults ($p=.01$; see Figure 1A). The significant main effect of Condition, $F(1.59,54.18) = 40.35$, $p<.001$, was driven by more detail for recalled events than imagined past ($p<.001$) and future ($p<.001$) events. Finally, the interaction of Detail × Condition, $F(2,68)=4.42$, $p=.02$, was significant (see Figure 1B). This effect reflected more external details being generated for future than past imagined events (p < .001), while a trend towards the reverse pattern – more details for past than future events – was evident for internal details (p = .08). Moreover, although recalled past events contained more internal details than both imagined past ($p = .02$) and future events ($p<.001$), recalled past events only contained more external detail relative to imagined past ($p <.001$) and not future ($p=.14$) events.

To test the effect of the recombination load manipulation on internal and external detail generated for imagined events, we computed a 2 (Condition: Past-Imagine, Future-Imagine) × 3 (Recombination Load: 1, 2, 3) × 2 (Detail: Internal, External) × 2 (Group: Young, Older) mixed factorial ANOVA with repeated factors of Condition, Recombination Load and Detail and between factor of Group. This analysis was conducted on a subset of the data in the first ANOVA (i.e., data for imagined events only), and thus the main effect of Detail, $F(1,34)=77.86$, $p<.001$, Detail × Group interaction, $F(1,34)=21.32$, $p<.001$, and Detail × Condition interaction, $F(1,34)=12.62$, $p<.001$, were evident again. Importantly, we found an effect of Recombination Load, $F(2, 68)=3.87$, $p=.03$, which was driven by a significant increase in the number of details imagined when the three presented details were drawn from the same event versus three different events ($p = .04$; see Figure 1C). No other effects were significant (p values $> .07$).

Correlations of AI scores across the three conditions were computed across all subjects. Importantly, the internal detail score correlated across events conditions (see Figure 1E–G for r and p values). External detail scores also correlated across event conditions (past-imagine and future-imagine, $r = .83$; past-imagine and past-recall, $r =.73$; future-imagine and past-recall, $r =.73$; all p values $< .001$). Within each of the age groups, the same pattern of significant correlations was evident for internal detail scores (past-imagine and future-imagine, young, $r = .83$, old, $r = .75$; past-imagine and past-recall, young, $r = .74$, old, $r = .77$; future-imagine and past-recall, young, $r = .68$, old, $r = .57$; all p values $\leq .01$) and external detail scores (past-imagine and future-imagine, young, $r = .79$, old, $r = .79$; past-imagine and past-recall, young, $r = .85$, old, $r = .55$; future-imagine and past-recall, young, $r = .77$, old, $r = .63$; all p values $\leq .02$). In contrast, internal and external scores were uncorrelated (past-imagine, $r =.077$; future-imagine, $r = -.148$; past-recall, $r = -.090$; all p values $> .05$). The same pattern of correlations was evident within each of the age groups for the future-imagine (young, $r = .23$, old, $r = -.02$) and past-recall (young, $r = -.03$, old, $r = .13$) conditions. In contrast, past-imagine internal and external scores were correlated in young ($r = .59$, p = .01) but not older ($r = -.04$, $p = .87$) adults.

Coinciding Details Score

As a measure of event integration, we scored how many of the critical details (person, place and object) coincided in the same temporal and spatial context for imagined events (see Table 1). First, Wilcoxin Signed Ranks Tests indicated this measure did not differ between past and future imagined events ($p = .989$). There was, however, a significant effect of recombination load. Although interactions cannot be tested directly when using non-parametric tests, we note that this effect of load was evident in both young ($p < .001$) and older ($p < .001$) adults. Post-hoc Wilcoxin Signed Ranks tests indicated that the effect of load was driven by significantly higher integration scores when all three details were originally drawn from one event versus two ($p < .001$) or three ($p < .001$) events (see Table 1). There was no significant difference in the coinciding details score when details were drawn from two or three events ($p = .116$). Mann Whitney U tests revealed that this coinciding details score was significantly lower in older adults both for imagined past ($p < .001$) and future ($p < .001$) events. Moreover, this group difference was only evident when the critical details were drawn from three past events ($p < .001$) but did not surpass the corrected significance threshold when the details were drawn from one ($p = .04$) or two ($p = .01$) details.

Discussion

The results reported here using a new experimental recombination task replicate and extend our previous findings of age-related deficits in the episodic simulation of future events (Addis et al., 2008). Our results demonstrate that the experimental recombination paradigm achieved the aim of requiring participants to recombine details when simulating an event. The difference between events imagined under conditions of high recombination load (when all three critical details were extracted from different events) and low recombination load (when all critical details came from the same event) mirrors the pattern of reported phenomenological differences between recalled past and imagined future events (e.g., Addis et al., 2009; D'Argembeau & van der Linden, 2004). For instance, events simulated under high recombination load were lower in internal and external detail, and were assigned lower subjective ratings of detail, emotion and personal significance, than events simulated under low recombination load. Interestingly, the rated similarity of imagined events to previous experiences declined with higher recombination load, and although the average similarity ratings still indicates the imagined events are novel, it does demonstrate that the recombination manipulation is effective in inducing people to simulate more highly novel, imaginary events.

Perhaps the most important finding is that age-related deficits in episodic simulation occurred under conditions that preclude recasting of remembered events as imagined events. As noted earlier, it could be argued that our initial observation of age-related deficits in imagining future events occurred because younger and older adults simply recast entire remembered events as imaginary future events. Because the experimental recombination task requires generation of novel events comprised of details from separate past episodes, the observed age-related reduction in internal (episodic) details for imagined events cannot be attributed to recasting of entire past episodes. Age-differences in the subjective ratings of the emotionality and personal significance of events also cannot explain age-differences on the AI internal detail scores, given that older adults made significant higher ratings than younger adults.

Two further observations point toward age-related problems in recombining event details as a key contributor to the observed impairments. First, age deficits were comparable for imagined future and imagined past events; both types of imagined events require recombining episodic details from different episodes. Second, age deficits were evident on the integration score that assesses how many critical details coincide in the same spatial and temporal context, indicating that older adults have problems constructing a unified episode on the basis of recombined event details, particularly if all the details are extracted from different past events.

A number of other interesting findings emerged from this study, including differences between imagined future and past events. Specifically, future events contained more external details than imagined past events, while there was a trend towards more internal details for imagined past versus future events. A somewhat speculative hypothesis is that because imagined past events are set in the same temporal direction as the past episodic events one draws upon for episodic detail, it may be easier to access and incorporate additional episodic detail when imagining past than future events. Future work is needed to determine whether or not this is a viable mechanism. Interestingly, both types of imagined events were responsive to the recombination manipulation, again supporting the idea that different forms of episodic simulation involve the recombination of various details into an integrated scenario.

All of the foregoing findings are consistent with predictions made by the constructive episodic simulation hypothesis (Schacter & Addis, 2007; 2009; see also Hassabis & Maguire, 2007), thereby providing further empirical support for this view. However, the present results still leave open a number of key issues and questions concerning the basis of age-related impairments in episodic simulation. Some of the age-related deficits we have documented could be attributable to general factors outside the domain of episodic memory that may be related to performance on the AI. For instance, studies from the verbal discourse literature have shown that older adults sometimes generate more "off topic" speech that is irrelevant to the assigned task than do younger adults (Arbuckle & Gold, 1993; James, Burke, Austin, & Hulme, 1998). Although relevant and irrelevant speech do not directly map onto the distinction in the AI between internal and external details, there may be some overlap between external details on the AI and irrelevant/off-topic speech. Production of off-topic speech could result from age-related deficits in inhibitory control (Zacks & Hasher, 1994) or differences in narrative style (Coupland & Coupland, 1995) and communicative goals when describing personal events (e.g., to convey the significance and meaning of experiences, James et al., 1998). Note, however, that if such differences were responsible for increased external and decreased internal details in older adults, one might expect to observe a negative correlation between external and internal details, but they were uncorrelated with one another (except for past-imagine events in young adults). Still, this finding does not rule out explanations based on inhibitory processes or narrative style, since increased external details in older adults, which are predicted by such explanations, need not necessarily be associated with reductions in internal details (see below). Future research that addresses the issue more directly is clearly needed.

While the underlying basis for the general lack of correlation between internal and external details is not entirely clear, one possibility is that generating internal details is driven by an episodic memory mechanism that is distinct from a semantic memory mechanism underlying the generation of external details. Another possibility is that a single mechanism underlies the generation of both internal and external details and that these scores are actually positively correlated. However, this might be obscured by a negative correlation (resulting in an overall zero correlation) between internal and external details, reflecting a trade-off between the detail types, such that producing more internal details leaves little time for producing external details and vice versa. A final possible reason for the lack of correlation between internal and external details is that differences in narrative style may result in a zero internal-external correlation, for instance, if some individuals focus on internal but not external details, while others focus on external and not internal details. Further research is needed to further clarify the mechanisms at work here, in both young and older adults.

Finally, it is important to note that related research has shown that older adults sometimes provide less detailed descriptions of presented pictures than do younger adults (Wright, Capitouto, Wagovich, Cranfill, & Davis, 2005). Although such effects are not always observed (Beaudreau, Storandt, & Strube, 2006; James et al., 1998), it is entirely conceivable that our results, as well as those of other using narrative techniques such as the AI, could be influenced by age differences in descriptive narration that are not restricted to the domain of episodic remembering or imagining, yet impact performance on tasks such as those used here.

Additional research will be required to assess the possible contribution of non-episodic factors to age-related deficits in episodic simulation. Nonetheless, the present results support the idea that age differences in the ability to recombine event details play an important role in the observed differences in constructive episodic simulation between younger and older adults.

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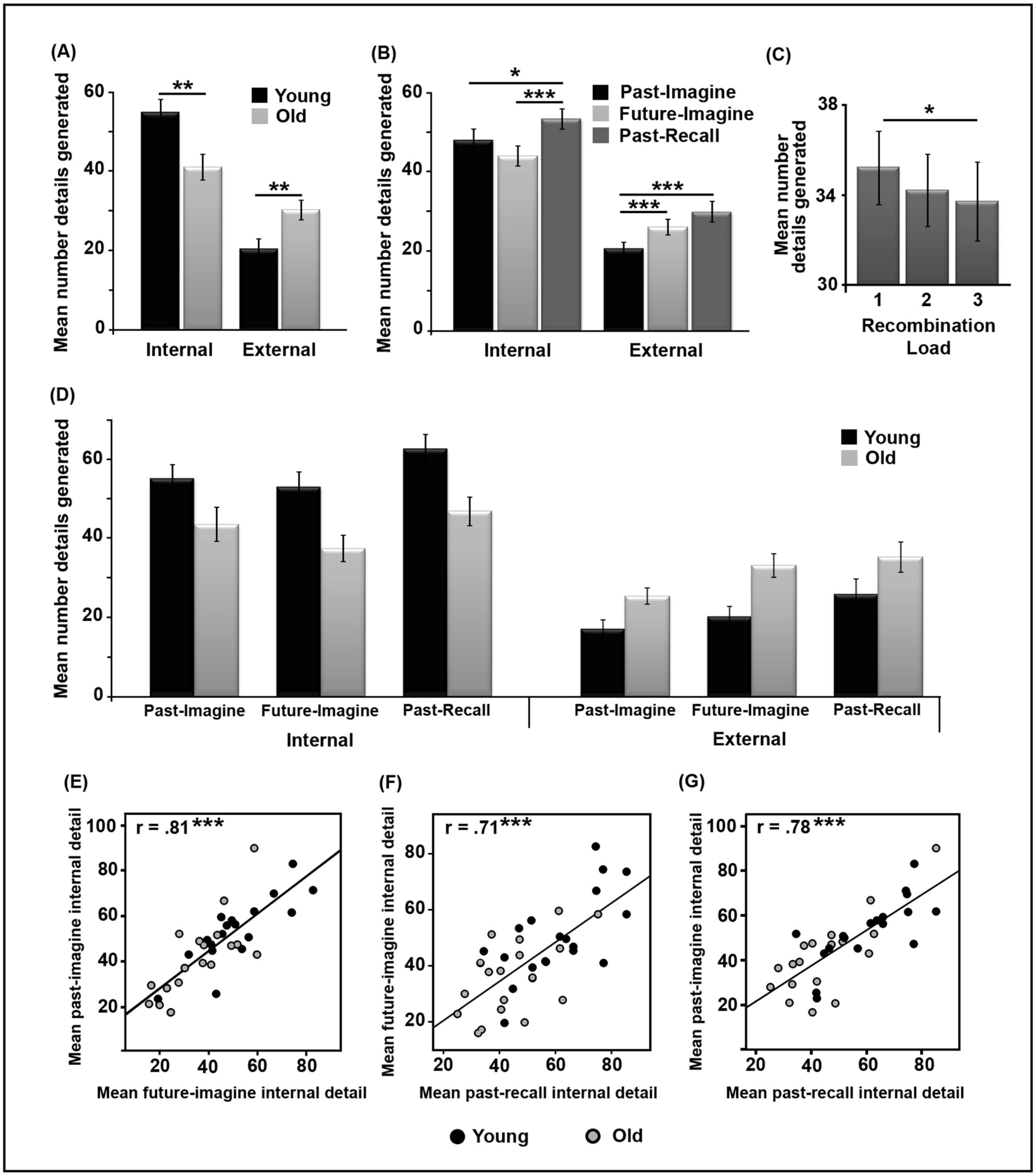

Figure 1.

Mean number of internal and external details as a function of (A) age group, (B) condition, and (D) age group and condition. The mean number of details (collapsed across internal and external) generated under the three recombination load conditions is shown in (C). Error bars represent standard errors of the means. Scatter plots and regression lines illustrate the correlations between the numbers of internal details generated for (E) imagined past and future events, (F) imagined future and recalled past events, and (G) imagined past and recalled past events. *p ≤ .05; **p ≤ .01; ***p ≤ .001.

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Table 1

Average phenomenological qualities of events generated by young and older adults.

A. Phenomenological Qualities of Recalled and Imagined Events by Event Condition

	Past-Imagine		Future-Imagine		Past-Recall	
	Young	**Old**	**Young**	**Old**	**Young**	**Old**
Temporal distance (weeks)†	64.1 (30.4)	59.1 (37.4)	71.1 (34.4)	83.6 (38.7)	53.0 (33.6)	57.9 (55.5)
Detail†††	3.01 (.83)	3.56 (.68)	2.98 (.63)	3.57 (.68)	3.88 (.60)	4.25 (.74)
Emotional intensity†††	2.39 (.80)	3.22 (.67)	2.51 (.69)	3.36 (.75)*	3.17 (.84)	3.76 (.76)
Personal significance††	2.12 (.81)	3.04 (.75)*	2.24 (.67)	3.11 (.82)	2.71 (1.0)	3.42 (1.1)
Similarity to past events	2.16 (.54)	2.79 (.52)	2.16 (.74)	2.62 (.68)	n/a	n/a
Coinciding detail score	2.90 (.12)*	2.38 (.33)	2.92 (.11)*	2.37 (.24)	n/a	n/a

B. Phenomenological Qualities of Imagined Events by Load Condition.

	Load 1		Load 2		Load 3	
	Young	**Old**	**Young**	**Old**	**Young**	**Old**
Temporal distance (weeks)	72.4 (25.2)	74.5 (36.4)	65.6 (33.1)	73.4 (44.2)	64.0 (35.1)	68.2 (29.4)
Detail††	3.15 (.73)	3.75 (.70)	2.97 (.67)	3.50 (.63)	2.85 (.73)	3.45 (.67)
Emotional intensity††	2.45 (.72)	3.44 (.72)*	2.57 (.76)	3.23 (.58)	2.31 (.75)	3.14 (.77)
Personal significance†	2.22 (.67)	3.10 (.80)*	2.17 (.88)	3.01 (.68)	2.05 (.69)	3.14 (.77)
Similarity to past events†††	2.56 (.62)	2.99 (.63)	2.07 (.63)	2.66 (.79)	1.84 (.71)	2.43 (.62)
Coinciding detail score†††	2.83 (.17)	2.66 (.28)	2.57 (.27)	2.27 (.35)	2.54 (.35)*	2.11 (.31)

Note. Standard deviations are given in parentheses.

* Significant group difference ($p \leq .001$, bonferroni corrected threshold), with the asterisk indicating the group with the higher score;

† Main effect of condition ($p \leq .05$);

†† Main effect of condition ($p \leq .01$);

††† Main effect of condition ($p \leq .001$).