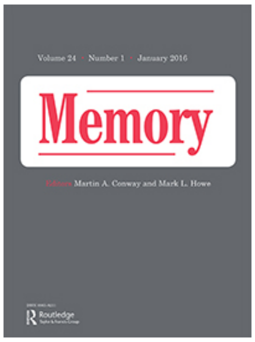

Memory

ISSN: 0965-8211 (Print) 1464-0686 (Online) Journal homepage: https://www.tandfonline.com/loi/pmem20

Divergent thinking and constructing episodic simulations

Donna Rose Addis, Ling Pan, Regina Musicaro & Daniel L. Schacter

To cite this article: Donna Rose Addis, Ling Pan, Regina Musicaro & Daniel L. Schacter (2016) Divergent thinking and constructing episodic simulations, Memory, 24:1, 89-97, DOI: 10.1080/09658211.2014.985591

To link to this article: https://doi.org/10.1080/09658211.2014.985591

Published online: 06 Dec 2014.

Memory, 2016
VOL. 24, NO. 1, 89–97, http://dx.doi.org/10.1080/09658211.2014.985591

Routledge
Taylor & Francis Group

Divergent thinking and constructing episodic simulations

Donna Rose Addis[1], Ling Pan[2], Regina Musicaro[2], and Daniel L. Schacter[2]

[1]School of Psychology and the Centre for Brain Research, The University of Auckland, Auckland, New Zealand
[2]Department of Psychology, Harvard University, Cambridge, MA, USA

(*Received 23 July 2014; accepted 4 November 2014*)

Divergent thinking likely plays an important role in simulating autobiographical events. We investigated whether divergent thinking is differentially associated with the ability to construct detailed imagined future and imagined past events as opposed to recalling past events. We also examined whether age differences in divergent thinking might underlie the reduced episodic detail generated by older adults. The richness of episodic detail comprising autobiographical events in young and older adults was assessed using the Autobiographical Interview. Divergent thinking abilities were measured using the Alternative Uses Task. Divergent thinking was significantly associated with the amount of episodic detail for imagined future events. Moreover, while age was significantly associated with imagined episodic detail, this effect was strongly related to age-related changes in episodic retrieval rather than divergent thinking.

Keywords: Episodic memory; Autobiographical; Ageing; Divergent thinking; Simulation; Prospection.

Divergent thinking—the ability to generate ideas by comparing and combining disparate forms of information in new ways—is closely linked to imagination (Durndell & Wetherick, 1976; Mednick, 1962). Divergent thinking is related to the quality of imagination in children (Russ, 2003) and mental imagery in adults (Durndell & Wetherick, 1976; Forisha, 1978; Schmeidler, 1965). We suggest that divergent thinking is also associated with the ability to create detailed simulations of autobiographical events, such as possible future experiences.

Akin to divergent thinking, simulation is a form of "productive imagination" (Burnham, 1892), involving the extraction of details from various episodic autobiographical memories which are recombined to create novel scenarios (for reviews of supporting evidence, see Addis & Schacter, 2012; Schacter et al., 2012; Szpunar, 2010). According to the constructive episodic simulation hypothesis, access to details in episodic memory is associated with the amount of episodic detail comprising simulations (Schacter & Addis, 2007). Indeed, the level of detail comprising memories

Address correspondence to: Donna Rose Addis, School of Psychology, The University of Auckland, Private Bag 92019, Auckland 1142, New Zealand. E-mail: d.addis@auckland.ac.nz

We thank Ryan Hunt, Melissa Inger and Jessica Mitchell for scoring of the Alternative Uses Task data, and Lucia Lee and Lara Markstein for transcribing and scoring Autobiographical Interview data.

This research was supported by National Institute on Aging [grant number AG08441], awarded to Daniel L. Schacter. Donna Rose Addis was supported by a Rutherford Discovery Fellowship [RDF-10-UOA-024].

of past events is strongly correlated with that of simulations (see Schacter, Gaesser, & Addis, 2013, for a review). However, retrieving details from memory is not sufficient; one has to organise disparate elements of information into a coherent form (Addis & Schacter, 2012), which may require recruitment of creative thought processes (Khatena, 1978), such as divergent thinking. Thus, the aim of this study is to investigate whether divergent thinking abilities are associated with the construction of detailed simulations over and above the ability to access detailed memories.

Little research has investigated the potential links between divergent thinking and autobiographical simulation. Ononye, Blinn-Pike and Smith (1993) found that performance on the Consequences Task (Guilford, 1967), which requires the generation of possible consequences and responses to non-personal futuristic problems (e.g., everyone suddenly loses the ability to read and write), was significantly associated with performance on the Future Problem-Solving Task, in which participants generated solutions for personal future problems (e.g., a dream job in a distant city). It is possible, however, that the similar structure of both tasks could explain, at least in part, the correlated performance. Moreover, while this study focused on the quantitative aspects of future thinking, divergent thinking may contribute to the *quality* of simulations—and may be particularly important for the richly detailed scenarios that typify episodic simulations (Schacter & Addis, 2007). The present study attempts to address this issue.

An additional question is whether divergent thinking is similarly related to the simulation of *any* autobiographical episode, whether the imagined event is located in the future or the past. We have previously found imagined past events to be similar to future simulations, both in terms of the amount of episodic detail (Addis, Musicaro, Pan, & Schacter, 2010) and neural correlates (Addis, Pan, Vu, Laiser, & Schacter, 2009). However, these events may differ in terms of opportunity for flexible, divergent thought. Although the imagined future is somewhat constrained by past experiences and plans, it can still be conceived as many branching possibilities (Goldie, 2009), while imagined past events are likely more constrained by what has actually occurred.

We also assessed whether previously documented differences between young and older adults in the amount of episodic detail comprising imagined events (cf., Addis, Wong, & Schacter, 2008; Addis et al., 2010; Cole, Morrison, & Conway, 2013; Rendell, Bailey, Henry, Phillips, Gaskin, & Kliegel, 2012; for review, see Schacter et al., 2013) are associated with the ability to retrieve episodic details from memory, or whether divergent thinking might also be relevant. Age-related declines on the Alternative Uses Task have been reported (e.g., Alpaugh et al., 1982), and age is a significant predictor of divergent thinking (Hendricks, 1999), but it remains unexplored whether declines or cohort differences in divergent thinking are important non-mnemonic factors in understanding age-related changes in the simulation of episodic events.

MATERIALS AND METHODS

Thirty-six participants (18 young: 9 males, M_{age} = 21.89 years, SD_{age} = 3.61; 18 older: 7 males, M_{age} = 74.89, SD_{age} = 5.56) who had participated in another study examining imagined future, imagined past and remembered past events (Addis et al., 2010) came back into the laboratory for additional testing of divergent thinking. Participants gave informed written consent for all testing sessions in a manner approved by the Harvard Institutional Review Board. Participants were fluent in English, had no history of neurological or psychiatric impairment; all older adults had a mini-mental state examination score of 27 or higher, excluding dementia. Older adults had completed more years of education than younger adults (older: M = 16.39 years, SD = 2.62; younger: M = 14.56, SD = 2.09; p = .026).

For a detailed description of the episodic simulation task used during Phase 1 of this experiment, see Addis et al. (2010). Briefly, during session 1, participants retrieved 35 memories from the past 5 years and specified 3 details for each: a person, object and location. In session 2, participants completed an adapted version of the Autobiographical Interview (AI; Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002) with three conditions: imagine-future, imagine-past and recall-past. On each trial, they were shown sets of details from their own memories recalled in session 1. For "past-recall" trials (4 trials), the detail set comprised a person, location and object from one memory and participants recalled the specified event. For past-imagine (4 trials) and future-imagine trials (4 trials), a set of person, location and object details drawn from different memories were shown,[1] and participants generated a plausible personal experience involving the specified details. For all conditions, events were required to be temporally and contextually specific (i.e., episodic) and located within 5 years from the present. General probes were given when needed to clarify instructions and encourage as much description of details as possible within the 3 minutes allocated for each trial. Trials were blocked according to condition; order was counterbalanced across participants. Transcribed interviews were scored using the standardised AI scoring procedure (Levine et al., 2002; for more information, see Addis et al., 2010); each distinct detail was classified as *internal* (episodic information relating to the central event being described) or *external* (non-episodic information including semantic details, extended events and repetitions). The average number of internal and external details for each participant in each condition was used in these analyses.

Approximately one month (M = 27.42 days, SD = 36.79) after session 2, participants were invited to the laboratory to complete session 3; this delay did not differ between groups (p = .265). Divergent thinking was assessed using the Alternative Uses Task (Guilford, 1967). Participants were instructed to generate as many uses as possible for a given item within a minute. Six items were used: eyeglasses, shoes, keys, button, wooden pencil and automobile tire. Participant responses were recorded and scored for standard measures of divergent thinking: *fluency* (total number of possible uses generated), *flexibility* (the number of distinct categories or groupings the responses could be divided into), *appropriateness* (appropriate uses received a score of 1 and inappropriate responses a score of 0), *elaboration* (0 points were given for brief descriptions of the use, e.g., "a doorstop"; 1 if more detail was given, e.g., "a doorstop to prevent a door slamming"; and 2 points if even further detail was given, e.g., "a doorstop to prevent a door slamming in a strong wind"), *originality* (calculated by comparing each response generated by a participant to the responses of all other participants; a score of 3 was assigned if less than 5% of other participants generated that response, 2 if 5–10% of other participants had the response, 1 if 10–15% of other participants had that response and 0 if more than 15% of other participants gave that response). Flexibility, appropriateness and elaboration were scored by three independent raters blind to group membership (fluency and originality scores were not subjected to an inter-rater reliability analysis as these scores were based on counts of responses or the distribution of responses across participants). Inter-rater reliability of these three divergent thinking measures was high; using a two-way mixed model, the standardised Cronbach's α was greater than .86 for each measure. As performance across the five measures was significantly inter-correlated (r values, .604–.998), scores were mean-centred and collapsed into a mean divergent thinking score for use in the regression analyses.

[1] Note that in the original study, there were additional imagine trials in which details came from one or two memories (i.e., a recombination load manipulation). However, in order to match trial numbers across memory and imagine trials for this analysis, we only included data from the imagine trials in which recombination of details was maximal.

RESULTS

Episodic simulation

We conducted a 3 (Condition: Past-Imagine, Future-Imagine and Past-Recall) × 2 (Detail: Internal and External) × 2 (Group: Young and Older) mixed factorial analysis of variance (ANOVA) with repeated factors of Condition and Detail and between factor of Group. Although this analysis was reported in Addis et al. (2010), we repeated the analysis here with the subset of imagined events used in the current study. The same effects of interest as those previously reported were also evident here, and the average internal and external detail scores according to condition and age group are provided in Table 1A. A main effect of Detail, $F_{(1, 34)}$ = 82.39, p < .001, reflected more internal than external details generated when describing events. There was also a crossover interaction of Detail and Group, $F_{(1, 34)}$ = 25.79, p < .001, where young adults generated more internal details than older adults (p = .005) and older adults generated more external details than young adults (p = .005). The main effect of Condition, $F_{(2, 68)}$ = 39.11, p < .001, was driven by more detail generated for recalled events than imagined past and future events (p-values < .001). Internal details were strongly correlated across the three conditions (r values >.68; p-values < .001), as were external details (r values >.59; p-values < .001).

TABLE 1
Autobiographical Interview and Alternative Uses Task: group performance and correlations

A. Autobiographical Interview Scores

	Mean (SD)					
	Future-imagine		*Past-imagine*		*Past-recall*	
AI score	*Younger*	*Older*	*Younger*	*Older*	*Younger*	*Older*
Internal detail[a]	51.75 (16.50)	32.15 (15.59)	52.58 (18.47)	39.67 (18.99)	60.56 (15.00)	45.17 (15.05)
External detail[b]	16.97 (11.66)	32.15 (15.59)	15.42 (8.77)	24.69 (9.46)	25.10 (15.47)	34.20 (15.78)

B. Alternate Uses Test scores and correlations with internal detail scores

	Mean (SD)		Correlation with AI internal detail scores		
AUT measure	*Younger*	*Older*	*Future-imagine*	*Past-imagine*	*Past-recall*
Fluency	6.45 (2.55)	5.52 (2.39)	.402**	.233	.097
Flexibility	4.55 (1.52)	3.833 (1.33)	.388**	.222	.110
Originality	8.37 (4.97)	7.96 (5.34)	.292*	.207	.022
Appropriateness	6.35 (2.47)	5.47 (2.40)	.413***	.247	.111
Elaboration	4.25 (2.37)	4.20 (1.81)	.374**	.304*	.258†

[a]Main effect of Group (Younger > Older), p = .005; [b]Main effect of Group (Older > Younger), p = .005.
***$p < .001$; **$p \leq .01$; *$p < .05$; †$p \leq .065$.
AI, Autobiographical Interview; AUT, Alternative Uses Task; SD, standard deviation.

Divergent thinking measures

We conducted a series of independent sample t-tests to determine whether there were age differences in the divergent thinking measures (see Table 1B). These analyses revealed that age did not affect performance on any of the five measures: fluency (t_{34} = 1.14, p = .26), flexibility (t_{34} = 1.51, p = .14), appropriateness (t_{34} = 1.10, p = .28), originality (t_{34} = .24, p = .81), elaboration (t_{34} = .07, p = .95) or the mean of these divergent thinking measures (t_{34} = .71, p = .49).

Relation between divergent thinking and episodic simulation

We were interested in whether divergent thinking abilities would be associated with the ability to generate detailed episodic simulations. We computed Pearson's product-moment correlations between the five divergent thinking measures and imagine-future, imagine-past and recall-past internal detail scores. As shown in Table 1B, all five measures were significantly correlated with the amount of internal episodic details comprising imagined future events. The elaboration score was also significantly correlated with the internal detail score for imagined past events and exhibited a trend for recalled past events (p = .065). None of the divergent thinking measures significantly correlated with the external detail score (all p-values >.084).

We conducted hierarchical linear regression analyses to determine whether the mean divergent thinking score could predict the amount of episodic detail comprising imagined future, imagined past and recalled events, even when age differences were controlled for (see Table 2A). First, age (in years) was entered into the models and was a significant predictor of the internal detail score for all event conditions, explaining approximately 14–26% of the variance in internal detail scores across the conditions. This finding is consistent with the age-related decreases in internal detail scores evident in the ANOVA analyses. In contrast, mean divergent thinking was only a significant predictor of the number of internal details generated for imagined future events, explaining an additional 11% of variance over and above age. It is possible that divergent thinking may be a significant predictor of internal details for the past-imagine and past-recall conditions if age is not already entered into the model. However, another set of regression analyses (Model 1 in Table 2B) with mean divergent thinking as the only predictor in the model indicated that this was not the case; once again, divergent thinking was a significant predictor of future-imagine internal detail only. We also ran this second set of regression analyses (Table 2B) to determine whether age could account for

TABLE 2
Linear regression analyses of age and divergent thinking on internal detail scores

A. Age and divergent thinking on internal detail scores

			Standardised beta coefficients	
Model	R^2	R^2 *change*	*Age*	*DT*
DV: future-imagine internal detail score				
1. Age	.243	.243**	−.493**	
2. Age, DT	.357	.114*	−.461**	.339*
DV: past-imagine internal detail score				
1. Age	.138	.138*	−.371*	
2. Age, DT	.185	.048	−.351*	.219
DV: past-recall internal detail score				
1. Age	.260	.260**	−.509**	
2. Age, DT	.263	.003	−.504**	.057

B. Divergent thinking and age on internal detail scores

			Standardised beta coefficients	
Model	R^2	R^2 *change*	*DT*	*Age*
DV: future-imagine internal detail score				
1. DT	.146	.146*	.382*	
2. DT, age	.357	.211**	.339*	−.461**
DV: past-imagine internal detail score				
1. DT	.063	.063	.252	
2. DT, age	.185	.122*	.219	−.351*
DV: past-recall internal detail score				
1. DT	.011	.011	.104	
2. DT, age	.263	.252**	.057	−.504**

**$p \leq .01$; *$p < .05$.
DT, divergent thinking; DV, dependent variable.

significant variance in the internal detail scores over and above divergent thinking. Indeed, this was the case for all conditions; even in the future-imagine condition, where mean divergent thinking was a significant predictor, age still accounted for a further 21% of variance.

Given the hypothesised link between retrieval of episodic detail and the amount of detail comprising imagined events, we also repeated the above hierarchical linear regressions for the imagined event conditions but included past-recall internal detail score as an additional variable in the model (see Table 3A). Again, age emerged as a significant predictor for internal details, but only when the sole predictor in the model. Once the past-recall internal detail score was entered, age was no longer a significant predictor, suggesting that the effect of age may be strongly related to reduced access to episodic detail. The past-recall internal detail score, however, was a highly significant predictor of the amount of imagined internal detail, explaining 27–34% of variance over and above age. Importantly, even with this highly significant variable in the model, mean divergent thinking still emerged as a significant predictor of imagined internal detail, but again only for future events. We also reran these regression analyses (Table 3B) adding age as the last predictor, to determine whether age could significantly account for variance in imagined internal detail over and above recalled internal detail and mean divergent thinking. Age was not a significant predictor for either of the imagine conditions. Interestingly, in the future condition, where divergent thinking was already entered as a significant predictor, the past-recall internal detail score still explained an additional 44% of the variance in internal detail (Table 3B, Model 2). In fact, for both imagined conditions, the model with divergent thinking and past-recall internal detail as predictors (Table 3B, Model 2) explained 51–59% of the variance in imagined internal detail, much higher than the model with divergent thinking and age as predictors (19–36% variance explained; Table 2, Model 2).

The pattern of results suggests that while divergent thinking is related to the amount of internal detail comprising imagined future events, this

TABLE 3
Linear regression analyses of age, past-recall internal detail score and divergent thinking on imagined internal detail scores

A. Age, past-recall internal detail score and divergent thinking on imagined internal detail scores

Model	R^2	R^2 *change*	*Standardised beta coefficients*		
			Age	*Past-recall*	*DT*
DV: future-imagine internal detail score					
1. Age	.243	.243**	−.493**		
2. Age, past-recall	.515	.272***	−.184	.606***	
3. Age, past-recall, DT	.607	.092**	−.168	.582***	.305**
DV: past-imagine internal detail score					
1. Age	.138	.138*	−.371*		
2. Age, past-recall	.482	.344***	−.024	.681***	
3. Age, past-recall, DT	.514	.032	−.014	.667***	.181

B. Divergent thinking, past-recall internal detail score and age on imagined internal detail scores

Model	R^2	R^2 *change*	*Standardised beta coefficients*		
			DT	*Past-recall*	*Age*
DV: future-imagine internal detail score					
1. DT	.146	.146*	.382*		
2. DT, past-recall	.586	.440***	.312**	.667***	
3. DT, past-recall, age	.607	.021	.305**	.582***	−.168
DV: past-imagine internal detail score					
1. DT	.063	.063	.252		
2. DT, past-recall	.514	.450***	.181	.675***	
3. DT, past-recall, age	.514	.000	.181	.667***	−.014

***$p < .001$; **$p \leq .01$; *$p < .05$.
DT, divergent thinking; DV, dependent variable.

relationship is not evident for imagined past events. In order to explore the significance of this apparent interaction, we ran a 2 (Condition: Past-Imagine and Future-Imagine) analysis of covariance with three covariates (Age Group, Past-Recall and Divergent Thinking) on the number of internal details. The key finding was that the Condition × Divergent Thinking interaction was not significant, $F_{(1, 32)} = 0.42$, $p = .52$, indicating that the relationship between divergent thinking was not significantly stronger for imagined future events relative to imagined past events.

DISCUSSION

The primary aim of this study was to determine whether divergent thinking abilities are associated with the construction of detailed future simulations over and above the ability to access episodic details, and if so, whether similar associations would be evident for imagined past events. We also explored whether previously documented differences between young and older adults in the amount of episodic detail comprising simulations are associated with age, memory ability and/or divergent thinking. While we found support for the hypothesis that divergent thinking is a significant predictor of the imagined internal detail score over and above memory for episodic details, this finding applied most strongly to imagined future events. Although it was not clearly evident for imagined past events, the fact that we failed to observe a significant interaction between imagination condition and divergent thinking in the model that included future and past imagination as dependent variables and divergent thinking, past recall and age as covariates indicates that we cannot draw strong conclusions concerning differences between future and past imagination. Moreover, while age was associated with the amount of detail comprising simulations, it appears that this effect may be strongly related to age-related changes in retrieving episodic detail.

However, our results do show clearly that divergent thinking abilities are strongly associated with future episodic detail. Importantly, the regression analyses showed that the predictive value of divergent thinking for future episodic detail was still evident even when variance due to age and retrieval of episodic detail (as indexed by the past-recall internal detail score) were accounted for. This observation is consistent with previous work linking divergent thinking with many of the cognitive processes required for future simulation, including mental imagery (e.g., Durndell & Wetherick, 1976), narrative abilities (e.g., Albert & Kormos, 2004) and associative processes (e.g., Mednick, 1962), as well as recent fMRI evidence (Benedek et al., 2014) that divergent thinking recruits some of the same default network regions typically linked with future simulation (e.g., Schacter, Addis, & Buckner, 2007; Schacter et al., 2012). It is notable, however, that many of these processes are thought to be required when imagining past events, and to some extent when recalling past events—and divergent thinking was not clearly associated with these conditions. Other investigators have also reported differences in imagining *future* scenarios compared with imagining atemporal scenarios, with age-related deficits exaggerated during the former compared with the latter (Rendell et al., 2012; for more general discussion, see Schacter et al., 2012). Although beyond the scope of this study, further work is needed to tease apart what aspects of the episodic content of future events (e.g., visuospatial content and narrative complexity) are most strongly related to particular forms of divergent thinking. Moreover, future work could address whether this relationship between divergent thinking and future simulation is still evident once individual differences in other related processes (e.g., general knowledge and vocabulary) are controlled for.

Interestingly, however, we did find one important similarity between imagined past and future events: access to episodic detail was a strong predictor for both forms of imagination. This finding is consistent with reports that a number of amnesic patients who cannot access episodic details show some impairment in imagining events (Hassabis, Kumaran, Vann, & Maguire, 2007; Klein, Loftus, & Kihlstrom, 2002; Kwan, Carson, Addis, & Rosenbaum, 2010; Tulving, 1985; for review, see Addis & Schacter, 2012). Moreover, recent evidence (Duff, Kurczek, Rubin, Cohen, & Tranel, 2013) indicates that a group of five amnesic patients were impaired in performance of the Torrance Tests of Creative Thinking, which tap divergent thinking processes. It is possible, however, that the degree of detail generated on these tasks reflects a general narrative style that is common to remembering and imagining any autobiographical episode. Speaking against this interpretation, we have previously found that episodic detail is associated with imagined detail even after controlling for narrative ability (Gaesser, Sacchetti, Addis, & Schacter, 2011), and recent data indicate that access to episodic details on tasks that tap remembering and imagining can be dissociated from performance on a narrative description task (Madore, Gaesser, & Schacter, 2014).

Once the past-recall internal score was entered into the model, age was no longer a significant predictor of imagined episodic detail, suggesting that the reduced ability of older adults to retrieve episodic details may underlie the age-related deficits in the episodic content of imagined events (Schacter et al., 2013). However, we did recently report in another ageing study examining future simulation that even after recalled episodic detail was entered into the regression model, age still predicted a small but significant portion of variance in the amount of future detail generated (Gaesser et al., 2011). A key difference between the two studies is that Gaesser et al. provided participants with detailed visual stimuli in the recall and imagination conditions, and it is possible that this externally provided detail may have slightly decreased the reliance on details retrieved from memory, allowing other age-related factors to emerge.

Although our findings demonstrate that divergent thinking abilities are associated with the generation of detailed future events, our results also suggest that age-related differences in future simulation are not simply due to cohort differences or age-related decline in divergent thinking abilities. We did not find any age differences in divergent thinking despite previous findings to the contrary (e.g., Alpaugh, Parham, Cole, & Birren, 1982; McCrae, Arenberg, & Costa, 1987). Moreover, even when divergent thinking was entered into the model first, a significant age effect was still evident and the R^2 change was similar in magnitude to when age was entered into the model first. This pattern suggests that other group differences are likely more important in explaining age-related reductions in episodic content—such as retrieval of episodic detail. This interpretation, however, does not negate the finding that divergent thinking is an important individual difference to consider when assessing future simulation abilities, irrespective of age.

Finally, another important question for future work concerns whether future simulation is also related to convergent thinking—the ability to generate the best single solution to a particular problem—or whether the link is selective to divergent thinking. Recent evidence indicates that associative false memory effects in the Deese–Roediger–McDermott (DRM) paradigm, where presentation of multiple associated words that converge on a non-presented lure word results in a high false alarm rate to the lure word on a subsequent recognition test (for review, see Gallo, 2010), are linked with convergent but not divergent thinking (Dewhurst, Thorley, Hammond, & Ormerod, 2011). Based on the present results and our characterisation of future simulation as involving the generation of multiple alternative scenarios, we expect that future simulation will exhibit the opposite pattern, i.e., though related to divergent thinking, it will not be significantly related to convergent thinking abilities.

In summary, the current study confirms that individual differences in divergent thinking are associated with the capacity for imagining future episodes. Although imagining a detailed scenario strongly relies on mnemonic factors, such as the retrieval of episodic details, divergent thinking is an important ingredient for future episodic thought across the lifespan.

REFERENCES

Addis, D. R., Musicaro, R., Pan, L., & Schacter, D. L. (2010). Episodic simulation of past and future events in older adults: Evidence from an experimental recombination task. *Psychology & Aging*, *25*, 369–376. doi:10.1037/a0017280

Addis, D. R., Pan, L., Vu, M.-A., Laiser, N., & Schacter, D. L. (2009). Constructive episodic simulation of the future and the past: Distinct subsystems of a core brain network mediate imagining and remembering. *Neuropsychologia*, *47*, 2222–2238. doi:10.1016/j.neuropsychologia.2008.10.026

Addis, D. R., & Schacter, D. L. (2012). The hippocampus and imagining the future: Where do we stand? *Frontiers in Human Neuroscience*, *5*, 173. doi:10.3389/fnhum.2011.00173

Addis, D. R., Wong, A. T., & Schacter, D. L. (2008). Age-related changes in the episodic simulation of future events. *Psychological Science*, *19*(1), 33–41. doi:10.1111/j.1467-9280.2008.02043.x

Albert, Á., & Kormos, J. (2004). Creativity and narrative task performance: An exploratory study. *Language Learning*, *54*, 277–310. doi:10.1111/j.1467-9922.2004.00256.x

Alpaugh, P. K., Parham, I. A., Cole, K. D., & Birren, J. E. (1982). Creativity in adulthood and old age: An exploratory study. *Educational Gerontology*, *8*(2), 101–116. doi:10.1080/0380127820080202

Benedek, M., Jauk, E., Fink, A., Koschutnig, K., Reishofer, G., Ebner, F., & Neubauer, A. C. (2014). To create or to recall? Neural mechanisms underlying the generation of new creative ideas. *NeuroImage*, *88*, 125–133. doi:10.1016/j.neuroimage.2013.11.021

Burnham, W. H. (1892). Individual differences in the imagination of children. *The Pedagogical Seminary*, *2*, 204–225. doi:10.1080/08919402.1982.10534017

Cole, S. N., Morrison, C. M., & Conway, M. A. (2013). Episodic future thinking: Linking neuropsychological performance with episodic detail in young and old adults. *Quarterly Journal of Experimental Psychology*, *66*, 1687–1706.

Dewhurst, S. A., Thorley, C., Hammond, E. R., & Ormerod, T. C. (2011). Convergent, but not divergent, thinking predicts susceptibility to associative memory illusions. *Personality and Individual Differences*, *51*(1), 73–76. doi:10.1016/j.paid.2011.03.018

Duff, M. C., Kurczek, J., Rubin, R., Cohen, N. J., & Tranel, D. (2013). Hippocampal amnesia disrupts creative thinking. *Hippocampus*, *23*, 1143–1149. doi:10.1002/hipo.22208

Durndell, A. J., & Wetherick, N. E. (1976). The relation of reported imagery to cognitive performance. *British Journal of Psychology*, *67*, 501–506. doi:10.1111/j.2044-8295.1976.tb01538.x

Forisha, B. L. (1978). Creativity and imagery in men and women. *Perceptual and Motor Skills*, *47*, 1255–1264. doi:10.2466/pms.1978.47.3f.1255

Gaesser, B., Sacchetti, D. C., Addis, D. R., & Schacter, D. L. (2011). Characterizing age-related changes in remembering the past and imagining the future. *Psychology and Aging*, *26*(1), 80–84. doi:10.1037/a0021054

Gallo, D. A. (2010). False memories and fantastic beliefs: 15 years of the DRM illusion. *Memory and Cognition*, *38*, 833–848. doi:10.3758/MC.38.7.833

Goldie, P. (2009). Narrative thinking, emotion, and planning. *The Journal of Aesthetics and Art Criticism*, *67*(1), 97–106. doi:10.1111/j.1540-6245.2008.01338.x

Guilford, J. P. (1967). *The nature of human intelligence*. New York, NY: McGraw-Hill.

Hassabis, D., Kumaran, D., Vann, S. D., & Maguire, E. A. (2007). Patients with hippocampal amnesia cannot imagine new experiences. *Proceedings of the National Academy of Sciences of the United States of America*, *104*, 1726–1731. doi:10.1073/pnas.0610561104

Hendricks, J. (1999). Creativity over the life course – A call for a relational perspective. *International Journal of Aging and Human Development*, *48*(2), 85–111. doi:10.2190/2566-WMYX-FJDU-4H9R

Khatena, J. (1978). Identification and stimulation of creative imagination imagery. *The Journal of Creative Behavior*, *12*(1), 30–38. doi:10.1002/j.2162-6057.1978.tb00157.x

Klein, S. B., Loftus, J., & Kihlstrom, J. F. (2002). Memory and temporal experience: The effects of episodic memory loss on an amnesic patient's ability to remember the past and imagine the future. *Social Cognition*, *20*, 353–379. doi:10.1521/soco.20.5.353.21125

Kwan, D., Carson, N., Addis, D. R., & Rosenbaum, R. S. (2010). Deficits in past remembering extend to future imagining in a case of developmental amnesia. *Neuropsychologia*, *48*, 3179–3186. doi:10.1016/j.neuropsychologia.2010.06.011

Levine, B., Svoboda, E., Hay, J. F., Winocur, G., & Moscovitch, M. (2002). Aging and autobiographical memory: Dissociating episodic from semantic retrieval. *Psychology & Aging*, *17*, 677–689. doi:10.1037/0882-7974.17.4.677

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, & Cognition*, *40*, 609–622. doi:10.1037/a0034885

McCrae, R. R., Arenberg, D., & Costa, P. T. (1987). Declines in divergent thinking with age: Cross-sectional, longitudinal, and cross-sequential analyses. *Psychology and Aging*, *2*(2), 130–137. doi:10.1037/0882-7974.2.2.130

Mednick, S. (1962). The associative basis of the creative process. *Psychological Review*, *69*, 220–232. doi:10.1037/h0048850

Ononye, G. C., Blinn-Pike, L. M., & Smith, D. E. (1993). Creativity and future time perspective: Exploring fantasy and realistic measures. *Creativity Research Journal*, *6*, 449–456. doi:10.1080/10400419309534499

Rendell, P. G., Bailey, P. E., Henry, J. D., Phillips, L. H., Gaskin, S., & Kliegel, M. (2012). Older adults have greater difficulty imagining future rather than atemporal experiments. *Psychology and Aging*, *27*, 1089–1098. doi:10.1037/a0029748

Russ, S. W. (2003). Play and creativity: Developmental issues. *Scandinavian Journal of Educational Research*, *47*, 291–303. doi:10.1080/00313830308594

Schacter, D. L., & Addis, D. R. (2007). The cognitive neuroscience of constructive memory: Remembering the past and imagining the future. *Philosophical Transactions of the Royal Society of London B*, *362*, 773–786. doi:10.1037/0033-295X.107.2.368

Schacter, D. L., Addis, D. R., & Buckner, R. L. (2007). Remembering the past to imagine the future: The prospective brain. *Nature Reviews Neuroscience*, *8*, 657–661. doi:10.1038/nrn2213

Schacter, D. L., Addis, D. R., Hassabis, D., Martin, V. C., Spreng, R. N., & Szpunar, K. K. (2012). The future of memory: Remembering, imagining, and the brain. *Neuron*, *76*, 677–694. doi:10.1016/j.neuron.2012.11.001

Schacter, D. L., Gaesser, B., & Addis, D. R. (2013). Remembering the past and imagining the future in the elderly. *Gerontology*, *59*, 143–151. doi:10.1159/000342198

Schmeidler, G. R. (1965). Visual imagery correlated to a measure of creativity. *Journal of Consulting Psychology*, *29*(1), 78–80. doi:10.1037/h0021660

Szpunar, K. K. (2010). Episodic future thought: An emerging concept. *Perspectives on Psychological Science*, *5*, 142–162. doi:10.1177/1745691610362350

Tulving, E. (1985). Memory and consciousness. *Canadian Psychology/Psychologie Canadienne*, *26*(1), 1–12. doi:10.1037/h0080017