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Individuals with highly superior autobiographical memory do not show enhanced creative thinking

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ABSTRACT

Creative ideas are thought to result from flexible recombination of concepts from memory. A growing number of behavioural and neuroscientific studies provide evidence of a link between episodic memory and divergent thinking; however, little is known about the potential contributions of autobiographical memory to creative ideation. To provide a novel perspective on this issue, we assessed measures of divergent and convergent creative thinking in a cohort (n = 14) of rare individuals showing Highly Superior Autobiographical Memory (HSAM). The HSAM cohort completed memory tasks in addition to a battery of creativity measures, including the Alternative Uses Task, Consequences Task and Remote Associates Task. We performed statistical analyses to establish whether there were any significant differences between HSAM and controls (n = 28) across these measures. Although HSAM participants were superior in the recall of autobiographical events compared to controls, we observed no overall difference between the groups in relation to the creativity measures. These findings suggest that the constructive episodic processes relevant to creative thinking are not enhanced in individuals with HSAM, perhaps because they are compulsively and narrowly focused on consolidation and retrieval of autobiographical events.

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Creativity is generally defined as the ability to generate novel and useful ideas to solve problems. Operationally, creativity can be measured in terms of both divergent and convergent thinking (Cropley, 2006; Guilford, 1967a, 1967b). Divergent thinking refers to the generation of multiple possible solutions to open-ended problems, whereas convergent thinking refers to finding the single best solution to a specific problem (Benedek et al., 2014; Japardi et al., 2018). The most common measure of divergent thinking is the Alternative Uses Task (AUT; Guilford, 1967b), by which participants are asked to generate novel uses for everyday objects. Assessments of divergent thinking are based not only on ideational fluency (number of ideas generated), but also on flexibility (number of different conceptual categories explored), originality (quality or novelty of ideas provided) and elaboration (number of details retrieved along with the basic ideas), among other factors. Convergent thinking is typically assessed via the Remote Associates Task (RAT; Mednick, 1962; Salvi et al., 2020) wherein participants think of a single word (e.g., bowl) that links triads of presented words (e.g., dust, cereal, fish). Taken together, divergent and convergent thinking characterise the process-oriented approach (Lin & Lien, 2013) rather than the product-oriented approach to creativity (e.g., Kaufman & Sternberg, 2010; Sternberg & Lubart, 1991), which, in turn, involves the ability to generate original and appropriate outcomes within real-world contexts (Bhattacharya & Petsche, 2005; Giancola et al., 2021; Palmiero et al., 2016).

Studies have begun to explore a possible link between episodic memory and creativity (Beaty & Schacter, 2018). Episodic memory is a cognitive system that supports the recollection of specific details of experiences (Tulving, 1983). Schacter and Addis (2007) argued that episodic retrieval enables us to recombine elements of experience in order to imagine novel future experiences and other kinds of hypothetical events, and there is considerable neural and cognitive evidence that supports this hypothesis (for a recent review, see Schacter & Addis, 2020). An emerging line of research has begun to explore the

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relationship between episodic retrieval and divergent thinking. Madore et al. (2015) showed that an Episodic Specificity Induction (ESI) – brief training in recollecting episodic details of a recent event – boosted performance on subsequent measures of generative output on the AUT, i.e., the fluency and flexibility of responses; however, this study found no effect of the ESI on convergent thinking as measured by the RAT. In a related study, Madore et al. (2016) found that the ESI boosted performance on the Consequences Task (Guilford, 1967b), a test of divergent thinking that requires generation of novel consequences of improbable scenarios that do not exist in everyday life. Subsequently, Madore et al. (2019) obtained brain imaging data from participants who performed the AUT after receiving either the ESI or a control induction. Results revealed increased neural activity in the hippocampus following the ESI. In light of considerable other data linking the hippocampus with episodic memory retrieval (for review, see Moscovitch et al., 2016), these findings provide further evidence that episodic retrieval may function as a component process of creative idea generation.

Neuroimaging studies using functional MRI have identified a core network of brain regions, including the hippocampus, that is jointly recruited during episodic memory retrieval, future imagining, and divergent creative thinking (Beaty et al., 2018). Additional studies have found hippocampal activation during generative modes of creative thinking (Benedek et al., 2014; Ellamil et al., 2012). More recently, Thakral et al. (2020) employed a transcranial magnetic stimulation (TMS) approach to further study the relationship between episodic simulation and divergent thinking. After receiving TMS to the left angular gyrus that resulted in a reduction of hippocampal activity, participants generated fewer creative ideas and produced fewer episodic details when imagining future events compared to performance in a control condition. This study provides causal evidence for the role of the hippocampus in both constructive episodic simulation and creative cognition. Taken together, these prior studies support the idea that episodic memory retrieval plays a role in divergent creative thinking.

Given the proposed link between episodic memory and creative thinking, in the present study we sought to extend this line of research to the closely related domain of autobiographical memory: the recollection of everyday personal experiences and knowledge. Few studies have explored potential links between creative thinking and autobiographical memory. While some researchers have argued that a well-developed autobiographical memory system is necessary for creative thinking, as it provides individuals with a rich storehouse of knowledge and experiences to draw upon when generating novel ideas (Conway & Pleydell-Pearce, 2000), others assert that autobiographical memory may impede creative cognition, as fixation on past experiences makes it difficult to generate original ideas (Weisberg, 2006). A recent study by Addis et al. (2016) found that the amount of episodic detail generated for simulated future events was associated with divergent thinking, but did not find a link between the amount of episodic detail generated for autobiographical memories and divergent thinking (for replication and extension, see Thakral et al., 2021).

To further examine the relationship between autobiographical memory and creative thinking, we assessed a cohort of 14 individuals with Highly Superior Autobiographical Memory (HSAM) on a battery of creativity measures. HSAM is characterised by the ability to recall events from past experiences, including the days and dates on which they occurred, with very high accuracy. The first modern case of HSAM was described by Parker and colleagues (2006), although evidence of individuals with extraordinary autobiographical memory dates back much farther (Henkle, 1871). Individuals with HSAM possess an extraordinary capacity to retrieve vast amounts of information about past personal experiences extending across much of their lifetimes (e.g., LePort et al., 2016, 2017; Parker et al., 2006; Santangelo et al., 2021). While HSAM individuals tend to exhibit a degree of obsessive-compulsive behaviours, they generally lead normal lives and view their memory ability as a positive attribute (LePort et al., 2012). Unlike other cases of superior memory, individuals with HSAM do not tend to use mnemonic strategies and do not report using memory rehearsal techniques (Patihis, 2016). fMRI evidence reveals that individuals with HSAM show increased brain activity in many more regions than control participants during retrieval of autobiographical memories, and also exhibit increased coupling between the hippocampus and prefrontal cortex (Santangelo et al., 2018), as well as increased cortical specialisation of the medial prefrontal cortex to distinguish the remoteness of past memories (Santangelo et al., 2020). Individuals with HSAM were also found to exhibit an altered pattern of hippocampal resting-state functional connectivity that may favour the encoding and consolidation of episodic details (Daviddi et al., 2022). In light of these findings and the observed evidence linking episodic retrieval and divergent creative thinking, it could be hypothesised on the one hand that more extensive access to past experiences from one's personal life, as in HSAM, enhances divergent thinking, especially fluency, flexibility and elaboration of idea generation. On the other hand, superior recollection of personal experiences may not be relevant to the constructive simulation processes that support creative cognition. Indeed, individuals with HSAM do not perform at a higher level than non-HSAM individuals on standard laboratory tests of episodic retrieval (LePort et al., 2012, 2017), and they are just as prone to memory distortions on several laboratory paradigms as are controls (Patihis et al., 2013). Thus, studying creative thinking in individuals with HSAM provides a novel way of testing the two foregoing hypotheses regarding the relation between enhanced autobiographical memory and creative cognition. To assess these hypotheses, we gave the AUT and Consequences Tasks, standard measures of divergent thinking, to individuals with HSAM and a control group. Although convergent thinking has not been strongly linked to episodic retrieval, to provide a broad assessment of creative cognition, we also administered the RAT to the HSAM and control groups.

Materials and methods

Participants

Individuals with HSAM were recruited within the Italian HSAM sample, previously screened within the Italian population in accordance with previous literature (e.g., LePort et al., 2012; see Santangelo et al., 2018, for the detailed screening procedure of the Italian HSAM sample). Fourteen individuals with HSAM (9 males; mean age: 35.07 ± 7.60 y.o.; range: 20–47 y.o.) were available to participate in the study. We also recruited a final number of twenty-eight[1] Italian control (i.e., normal-memory) subjects (16 males; mean age: 35.14 ± 6.52 y.o.; range: 25–48 y.o.), who were recruited using notices on social media and on bulletin boards of researchers. The two groups were matched for age [two-tailed independent-sample t-test: $t(40) = -0.032$, $p = 0.975$, Cohen's $d = -0.010$, Cohen's d 95% CI = −0.652, 0.631], gender [Pearson's X^2 (1, N = 42) = 0.198, $p = 0.657$, $\phi = 0.069$] and education [$t(40) = -0.157$, $p = 0.876$, $d = -0.051$, d 95% CI = −0.693, 0.591] (Table 1). All of the participants were naïve to the main purpose of the study, which was conducted in adherence to the tenets of the Declaration of Helsinki. All participants volunteered for this study and provided informed consent before starting the experiment.

Tasks

We assessed participants' ability to recollect public and personal past events using the Public Event Quiz and the Random Dates Quiz (LePort et al., 2012). The Public Events Quiz consisted of thirty questions, based on public events selected from five categories: sporting events, political events, notable negative events, events concerning famous people and holidays. For fifteen of these questions, participants were asked to retrieve the date of a given significant public (national or international) event (e.g., "Please give the day of the week and precise date with day, month and year of when Federica Pellegrini, the famous Italian swimmer, won the gold medal at the Olympic game in Beijing"); the remaining fifteen questions requested participants to associate a given date with a highly significant public event (e.g., "What happened on the 25th of June 2009?"). All questions concerned events that took place when the participants were at least 8 years old. For each question, individuals were asked to name the day of the week on which the date fell. One point was awarded for each correct response (i.e., the event, the day of the week, the month, the date and the year); the maximum total score was 88 points. The Random Dates Quiz consisted of ten computer-generated random dates, ranging from the individuals' age of fifteen to five years before the testing. Individuals were asked to provide three details for each date: (1) the day of the week; (2) a description of a verifiable event (i.e., any event that could be confirmed via a search engine) that occurred within a few days before and after the generated date; (3) a description of a personal autobiographical event. One point each was awarded for the correct day of the week, a correct public event, and unverified personal autobiographical memory. A maximum of three points per date could be achieved (30 points total).

The participants were then administered the main three tasks related to divergent/convergent thinking, namely, the Alternative Uses Task (AUT; Guilford, 1967b) and the Consequences Task (CT; Guilford, 1967b) to investigate divergent thinking, and the Italian version of the Remote Associates Task (RAT; Salvi et al., 2020) to examine convergent thinking. Moreover, they were also administered the Digit Span task (both forward and backward; Monaco et al., 2013) to measure working memory capacity, since working memory was found to be related to both divergent and convergent thinking (see, e.g., Lee & Therriault, 2013).

AUT

In this task, the participants were presented with a sequence of three common objects in a counterbalanced order: brick, newspaper, and shoe. For each object, the participants were required to list all the possible alternative uses within a time window of 3 min. They were instructed to be as fluent and creative as possible and use all the time available. Before starting the task, participants completed an example trial (i.e., paper clip). After completing the task, participants were asked to verbally rate each idea they generated (i.e., each alternative use for the object) as "old" (i.e., the idea comes to mind from a memory or reflects general knowledge, that was already known and did not involve a creative process) or as "new" (i.e., the idea comes to mind for the first time during the task, thus it was a spontaneous creative act in which unrelated

Table 1. Age, sex and education of HSAM and control (CNTR) subjects.

	Age	Sex		Education			
	Mean (SD)	M	F	% High School Diploma	% Bachelor Degree	% Master Degree	% Higher Qualification
HSAM	35.07 (7.60)	9	5	14.29	14.29	57.14	14.29
CNTR	35.14 (6.52)	16	12	10.71	14.29	60.71	14.29

Note: HSAM = Highly Superior Autobiographical Memory; SD = Standard Deviation.

information was associated in a new way) (see Benedek et al., 2014).

CT

In this task, participants were asked to think about the possible consequences of an unlikely scenario within a time window of 3 min. Again, they were instructed to be as fluent and creative as possible, and to use all the time available. Three different scenarios were presented, counterbalanced across participants: "What would the consequences be if humans could fly without mechanical aids?", "What would the consequences be if human life continued on earth without death?", and "What would the consequences be if the language of animals could be understood by humans?". The example trial was: "What would be the consequences if there were ropes that start from the clouds and reach the ground?". As for the AUT, after the conclusion of the task, the participants were asked to verbally rate whether the idea behind each response they generated was old or new.

RAT

In this task, participants were asked to find a target word (e.g., synthesis) that could be related to a set of three test words (e.g., photo, summary, and book) in order to form: a compound word (e.g., photosynthesis), a synonymous (e.g., synthesis = summary), and a semantic association (e.g., book synthesis). For each triad, participants had 30 s to write the target word. The triads had different degrees of difficulty equally distributed (i.e., low, medium, and high) and were presented in a random order for each participant, for a total of thirty triads (see Table S1 in the SI file). Before starting the task, an example trial was given to the participants (i.e., "eight-patrol-disk").

Digit span

In this task, the researcher read aloud a series of digits at a rate of one digit per second, and the participant's task was to repeat the number sequence immediately after. In the forward condition, the participants had to repeat the numbers in the same order, whereas in the backward condition the participants had to repeat the numbers in the reverse order. The number series gradually increases in length (i.e., the number of digits started from a three-digit or a two-digit sequence in the forward and backward condition, respectively) and the participants memory span was the longest sequence correctly repeated at least once.

Procedure

Due to the restrictions imposed by the Covid-19 pandemic, the tasks were administered remotely, using the video call platform most accessible for each participant, among Google Meet, Skype, Zoom, Microsoft Teams, and WhatsApp. After the preliminary evaluation of autobiographical memory, the other four tasks were administered in a counterbalanced order across participants. Each task started with the researcher reading aloud the specific instruction, followed by example trials. For the divergent and convergent tasks, the researcher wrote in the chat box of the selected platform the object name (AUT), the scenario (CT), or the triad (RAT), one at a time. The participants provided their answers in a written form, i.e., using the chat box, while the researcher kept the time allowed for each specific task. The digit span task was administered verbally. The total duration of the entire experiment was approximately 70 minutes.

Scoring

Both divergent thinking tasks (i.e., AUT and CT) were scored by three independent judges, blind to the hypothesis, in terms of four indices: 1) fluency, i.e., the number of appropriate generated uses and consequences, excluding repetitions; 2) originality, i.e., the quality of responses, according to uncommonness, cleverness, and remoteness, using a scale from 1 (low originality) to 5 (high originality). Judges were instructed to weigh the dimensions and give one single score for each response; then, each response was given a single evaluation score, by averaging the three judges' scores. The total originality score was computed for each participant by dividing the sum of response evaluations by the number of responses provided across the three stimuli; 3) flexibility, i.e., the number of absolute categories encompassing the responses; 4) elaboration, i.e., the number of details provided along with the basic responses, evaluated on a scale from 0 (brief description) to 2 (very detailed). The inter-rater reliability was high both for the AUT (fluency: $\alpha = 1$; originality: $\alpha = 0.953$; flexibility: $\alpha = 0.954$; elaboration: $\alpha = 0.850$) and the CT (fluency: $\alpha = 1$; originality: $\alpha = 0.953$; flexibility: $\alpha = 0.938$; elaboration: $\alpha = 0.876$). Then, in order to compute a composite score of divergent thinking, for each task (AUT and CT), fluency, originality, flexibility, and elaboration were transformed in z-scores and then averaged (see Runco et al., 2010). In addition, the total number of old or new ideas was also measured, as the two groups differed in terms of autobiographical memory capabilities.

For the RAT, the total number of correct responses was computed for each participant.

Finally, forward and backward digit span memory performances were corrected for age and education using the equivalent scoring system (cf. Monaco et al., 2013).

Statistical analysis

First, descriptive statistics were computed. Then, two-tailed two-sample t-tests were carried out in order to assess group differences in each single parameter of creativity tasks: AUT and CT fluency, flexibility, originality, elaboration; RAT scores. Two-sample t-tests were also performed to check for group differences in the covariates, that is, in forward/backward working memory scores and in the number of old/new ideas (for details, see Table 2).

Thus, for the divergent thinking tasks several analyses of covariance (ANCOVAs) were performed using Group as independent variable, and either the forward/backward working memory scores (see Table 3) or the number of old/new ideas separately as covariates (see Table 4). For convergent thinking, the ANCOVAs were performed using Group as independent variable and only the forward/backward working memory scores as covariates (see Table 3).

Results

As concerns the autobiographical memory, participants with HSAM performed significantly better than controls on the Public Event Quiz [Mean (SD): 58.20% (14.38) vs. 10.39% (4.73); $t(40) = 16.098$, $p < 0.001$, $d = 5.269$, d 95% CI = 3.944, 6.578] and the Random Dates Quiz [68.57% (20.07) vs. 2.62% (4.09); $t(40) = 16.893$; $p < 0.001$, $d = 5.530$, d 95% CI = 4.154, 6.888], confirming large differences on measures related to autobiographical memory between the two groups (Table 2 and Figure 1A).

Regarding the measures of creative thinking, the results revealed no significant differences between the two groups in the scores related to the divergent thinking tasks (all ts ranging between −1.595 and 1.126, all ps > 0.119; see Table 2 for details and Figure 1B & C). Similarly, no group differences were found using the composite scores: AUT [$t(40) = -0.268$, $p = 0.790$, $d = -0.088$, d 95% CI = −0.729, 0.555]; CT [$t(40) = 0.273$, $p = 0.786$, $d = 0.089$, d 95% CI = −0.553, 0.731]. Analogously, no group differences were found in the accuracy of the RAT [$t(40) = -0.364$, $p = 0.718$, $d = -0.119$, d 95% CI = −0.761, 0.524] (see Figure 1D).

As concerns the covariates, no group differences were found when considering working memory performance, both in terms of forward [$t(40) = 0.964$, $p = 0.341$, $d = 0.316$, d 95% CI = −0.332, 0.959] and backward [$t(40) = 0.912$, $p = 0.367$, $d = 0.299$, d 95% CI = −0.348, 0.942] digit span (see Figure 1E). In addition, no group differences emerged in the number of old-new ideas, for

Table 2. The table summarises the performance of HSAM and control (CNTR) subjects in the Public Event Quiz, Random Dates Quiz, AUT, CT, RAT, and Digit span task. For each task parameter, the mean (with standard deviation), the minimum and maximum scores, the 95% CI lower and upper level values, and the mean difference (t, p, Cohen's d and *d* 95% CI lower and upper level values derived from two-tailed two-sample t-tests) were reported.

		HSAM Mean (SD), min – max, 95% CI [LL, UL]	CNTR Mean (SD), min – max, 95% CI [LL, UL]	Mean difference t, *p*, d, d 95% CI [LL, UL]
Autobiographical memory screening tests				
Public Event quiz		58.20% (14.38), 86.36% – 36.36%, [49.89, 66.50]	10.39% (4.73), 1.14% – 22.73%, [8.56, 12.22]	16.098, <0.001*, 5.269, [3.944, 6.578]
Random Dates quiz		68.57% (20.07), 96.67% – 30.00%, [56.98, 80.16]	2.62% (4.09), 0% –13.33%, [1.03, 4.21]	16.893, <0.001*, 5.530, [4.154, 6.888]
Divergent Thinking				
AUT	Fluency	17 (6.50), 6 – 26, [13.24, 20.76]	18.32 (7.57), 9 – 35, [15.39, 21.26]	−0.557, 0.580, −0.182, [−0.824, 0.461]
	Originality	2.00 (0.43), 1.28 – 2.65, [1.75, 2.25]	1.82 (0.52), 1.60 – 3.06, [1.62, 2.02]	1.126, 0.267, 0.369, [−0.280, 1.013]
	Flexibility	0.79 (0.13), 0.44 – 0.91, [0.71, 0.87]	0.81 (0.09), 0.59 – 0.95, [0.78, 0.84]	−0.652, 0.518, −0.213, [−0.855, 0.431]
	Elaboration	0.54 (0.41), 0.06 – 1.48, [0.30, 0.78]	0.52 (0.45), 0.02 – 1.00, [0.35, 0.69]	0.122, 0.903, 0.040, [−0.602, 0.681]
CT	Fluency	14.79 (7), 3 –24, [10.75, 18.83]	14.54 (5.34), 6 – 25, [12.47, 16.61]	0.129, 0.898, 0.042, [−0.600, 0.684]
	Originality	2.24 (0.37), 1.62 – 2.72, [2.03, 2.45]	2.10 (0.53), 1.94 – 3.24, [1.90, 2.30]	0.881, 0.384, 0.288, [−0.358, 0.931]
	Flexibility	0.82 (0.10), 0.65 – 1, [0.76, 0.88]	0.87 (0.09), 0.65 – 1, [0.84, 0.90]	−1.595, 0.119, −0.522, [−1.171, 0.133]
	Elaboration	1.11 (0.45), 0.29 – 1.80, [0.85, 1.37]	0.97 (0.48), 0.11 – 1.88, [0.78, 1.16]	0.915, 0.366, 0.299, [−0.347, 0.942]
Convergent Thinking				
RAT	Correct responses	17.21 (4.81), 8 – 24, [14.43, 19.99]	17.68 (3.37), 11 – 25, [16.37, 18.98]	−0.364, 0.718, −0.119, [−0.761, 0.524]
Covariates				
Digit span task	Forward equivalent scores	3.36 (1.08), 0 – 4, [2.73, 3.98]	3.00 (1.15), 0 – 4, [2.55, 3.45]	0.964, 0.341, 0.316, [−0.332, 0.959]
	Backward equivalent scores	3.36 (1.15), 1 – 4, [2.69, 4.02]	3.00 (1.22), 0 – 4, [2.53, 3.47]	0.912, 0.367, 0.299, [−0.348, 0.942]
AUT	Old ideas	11.43 (4.13), 5– 17, [9.05, 13.81]	11.32 (5.25), 4 – 25, [9.28, 13.36]	0.067, 0.947, 0.022, [−0.620, 0.663]
	New Ideas	5.57 (3.90), 1 – 13, [3.32, 7.82]	7.00 (5.42), 2 – 23, [4.90, 9.10]	−0.878, 0.385, −0.287, [−0.930, 0.359]
CT	Old ideas	7.57 (5.49), 1 – 18, [4.40, 10.74]	5.64 (4.16), 0 – 19, [4.03, 7.25]	1.272, 0.211, 0.416, [−0.234, 1.062]
	New Ideas	7.21 (5.59), 1 – 22, [3.98, 10.44]	8.89 (4.72), 1 – 19, [7.06, 10.72]	−1.021, 0.313, −0.334, [−0.978, 0.314]

Note: HSAM = Highly Superior Autobiographical Memory; CI = Confidence Interval; LL = Lower Level; UL = Upper Level; AUT = Alternative Uses Task; CT = Consequence Task; RAT = Remote Associates Task.

Table 3. The table reports F, *p*, η^2 and 95% CI lower and upper level values related to the ANCOVAs conducted on the performances of the divergent and convergent thinking tasks, with the Group as independent variable and the digit-forward and digit-backward scores as covariates.

		Group F, *p*, η^2, 95% CI [LL, UL]	Digit-forward covariate F, *p*, η^2, 95% CI [LL, UL]	Digit-backward covariate F, *p*, η^2, 95% CI [LL, UL]
Divergent Thinking				
AUT	Fluency	0.453, 0.505, 0.012, [−3.308, 6.606]	0.950, 0.336, 0.024, [−1.086, 3.104]	0.009, 0.925, < 0.001, [−2.074, 1.890]
	Originality	1.565, 0.219, 0.036, [−0.534, 0.126]	2.676, 0.110, 0.062, [−0.252, 0.027]	0.651, 0.425, 0.015, [−0.079, 0.185]
	Flexibility	0.582, 0.450, 0.013, [−0.043, 0.095]	3.368, 0.074, 0.078, [−0.003, 0.056]	1.444, 0.237, 0.033, [−0.044, 0.011]
	Elaboration	0.001, 0.975, < 0.001, [−0.286, 0.295]	3.134, 0.085, 0.075, [−0.015, 0.230]	0.629, 0.432, 0.015, [−0.162, 0.071]
	Composite score	0.179, 0.674, 0.004 [−0.260, 0.397]	2.278, 0.139, 0.056, [−0.035, 0.242]	0.228, 0.636, 0.006, [−0.162, 0.100]
CT	Fluency	0.017, 0.897, .< 0.001, [−3.719, 4.233]	0.072, 0.789, 0.002, [−1.457, 1.904]	2.322, 0.136, 0.057, [−0.393, 2.786]
	Originality	0.478, 0.494, 0.012, [−0.445, 0.218]	0.184, 0.670, 0.005, [−0.110, 0.170]	0.431, 0.515, 0.011, [−0.090, 0.175]
	Flexibility	2.140, 0.152, 0.050, [−0.018, 0.112]	0.475, 0.495, 0.011, [−0.018, 0.037]	2.301, 0.138, 0.054, [−0.046, 0.007]
	Elaboration	0.452, 0.506, 0.011, [−0.417, 0.209]	3.320, 0.076, 0.079, [−0.013, 0.251]	0.059, 0.809, 0.001, [−0.140, 0.110]
	Composite score	0.016, 0.900, < 0.001, [−0.228, 0.258]	2.698, 0.109, 0.064, [−0.019, 0.186]	1.162, 0.288, 0.028, [−0.045, 0.149]
Convergent Thinking				
RAT	Correct responses	1.454, 0.235, 0.027, [−0.910, 3.591]	8.492, 0.006*, 0.158, [0.418, 2.320]	5.956, 0.019*, 0.110, [0.185, 1.984]

Note: AUT = Alternative Uses Task; CI = Confidence Interval; LL = Lower Level; UL = Upper Level; CT = Consequence Task; RAT = Remote Associates Task.

Table 4. The table reports all the ANCOVAs conducted on the performances of divergent and convergent thinking tasks, with the Group as independent variable and the number of old and new ideas separately as covariates. All F, *p*, η^2 and 95% CI lower and upper level values were reported.

		Group F, *p*, η^2, 95% CI [LL, UL]	Old ideas covariate F, *p*, η^2, 95% CI [LL, UL]	Group F, *p*, η^2, 95% CI [LL, UL]	New ideas covariate F, *p*, η^2, 95% CI [LL, UL]
Divergent Thinking					
AUT	Fluency	0.763, 0.388, 0.009, [−1.890, 4.763]	44.146, < 0.001*, 0.526, [0.747, 1.401]	0.016, 0.899, <0.001, [−3.527, 3.106]	46.204, < 0.001*, 0.542, [0.753, 1.391]
	Originality	1.234, 0.273, 0.031 [−0.514, 0.150]	0.015, 0.902, < 0.001 [−0.031, 0.035]	2.048, 0.160, 0.045 [−0.545, 0.093]	3.991, 0.053, 0.089 [0.000, 0.061]
	Flexibility	0.421, 0.520, 0.010 [−0.046, 0.090]	2.828, 0.101, 0.067 [−0.012, 0.001]	0.753, 0.391, 0.018 [−0.040, 0.099]	2.370, 0.132, 0.056 [−0.012, 0.002]
	Elaboration	0.021, 0.885, < 0.001 [−0.302, 0.262]	3.365, 0.074, 0.079 [−0.053, 0.003]	0.023, 0.881, < 0.001 [−0.318, 0.274]	0.052, 0.821, 0.001 [−0.025, 0.032]
	Composite score	0.107, 0.745, 0.002 [−0.246, 0.341]	9.438, 0.004*, 0.194 [0.015, 0.073]	0.158, 0.693, 0.002 [−0.299, 0.201]	29.308, < 0.001*, 0.428, [0.040, 0.088]
CT	Fluency	0.497, 0.485, 0.009 [−2.168, 4.488]	18.878, < 0.001*, 0.323 [0.391, 1.071]	1.051, 0.312, 0.015 [−4.592, 1.502]	29.078, < 0.001*, 0.421, [0.482, 1.061]
	Originality	0.525, 0.473, 0.013 [−0.446, 0.211]	0.453, 0.505, 0.011 [−0.022, 0.045]	0.536, 0.469, 0.013 [−0.442, 0.207]	0.708, 0.405, 0.018 [−0.044, 0.018]
	Flexibility	2.025, 0.163, 0.049 [−0.020, 0.112]	0.431, 0.515, 0.010 [−0.009, 0.005]	10.167, 0.003*, 0.116 [0.027, 0.120]	38.796, < 0.001*, 0.441 [−0.018, −0.009]
	Elaboration	1.004, 0.323, 0.025 [−0.480, 0.162]	0.326, 0.572, 0.008 [−0.042, 0.024]	0.286, 0.596, 0.006 [−0.370, 0.215]	7.650, 0.009*, 0.163 [−0.066, −0.010]
	Composite score	0.256, 0.616, 0.005 [−0.158, 0.263]	17.452, < 0.001*, 0.308 [0.023, 0.066]	0.121, 0.729, 0.003 [−0.294, 0.208]	0.263, 0.611, 0.007 [−0.018, 0.030]

Note: CI = Confidence Interval; LL = Lower Level; UL = Upper Level; AUT = Alternative Uses Task; CT = Consequence Task.

both divergent thinking tasks: AUT-Old ideas [$t(40) = 0.067$, $p = 0.947$, $d = 0.022$, d 95% CI = −0.620, 0.663], AUT-New ideas [$t(40) = -0.878$, $p = 0.385$, $d = -0.287$, d 95% CI = −0.930, 0.359] (Figure 1F); CT-Old ideas [$t(40) = 1.272$, $p = 0.211$, $d = 0.416$, d 95% CI = −0.234, 1.062], CT-New ideas [$t(40) = -1.021$, $p = 0.313$, $d = -0.334$, d 95% CI = −0.978, 0.314] (Figure 1G).

As for the ANCOVAs, for the divergent thinking tasks, no group difference was found in both AUT, CT and composite scores when using either forward/backward scores as covariates (p values ranging between 0.152–0.975; see Table 3). Then, no group differences were found in AUT, CT and composite scores when using the number of old/new ideas as covariate (p values ranging between 0.160–0.899; Table 4), with the exception of CT-Flexibility score with the new ideas covariate [$F(1,40)=10.167$, $p < 0.005$, $\eta^2 = 0.116$, 95% CI = 0.027, 0.120]: control subject obtain a higher score (0.87 ± 0.09) compared to the HSAM group (0.82 ± 0.10). As concerns the covariates in the group analyses, results were as follows: the old ideas covariate was significant for AUT-Fluency, AUT-Composite score, CT-Fluency, and CT-Composite score. In addition,

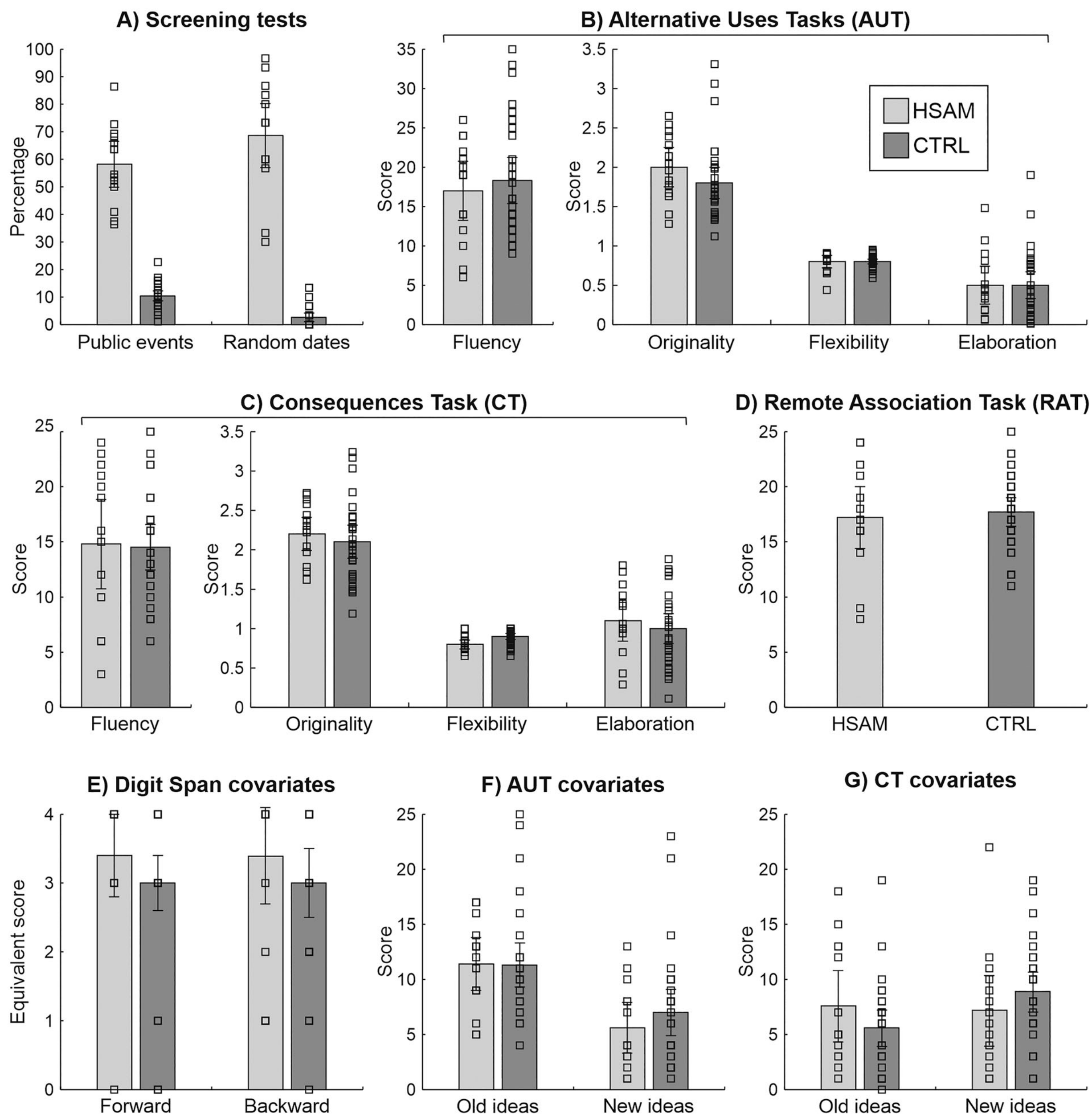

Figure 1. Mean ± 95% Confidence Intervals (CI) for HSAM and control subjects (light grey and dark grey bars, respectively) at the screening tests (panel A), AUT (panel B), CT (panel C), RAT (panel D), Digit span (E), AUT (panel F) and CT (panel G) covariates. In all graphs, squares indicate individual values.

the new ideas covariate was significant for AUT-Fluency, AUT-Composite score, CT-Fluency, and CT-Elaboration (see Table 4 for details). Similarly, for the RAT correct responses we found no group differences either, but significant digit-forward and backward covariates were observed (Table 3).

Discussion

HSAM has been characterised as the ability to recall events from personal past experiences with very high accuracy, including the specific dates on which they occurred. Individuals with HSAM demonstrate an exceptional ability to vividly recall many autobiographical details without using mnemonic strategies (Parker et al., 2006). Despite this extraordinary memory for personally experienced events, their performance on traditional laboratory measures is generally comparable to that of healthy controls, suggesting that generally superior cognitive functioning is not the basis of HSAM (LePort et al., 2012, 2017). The present study extends this line of research to creative thinking, observing no difference between HSAM and healthy controls in their performance on measures of divergent and convergent thinking. Thus, our findings do not reveal any significant differences in creative performance between HSAM individuals and controls.

As discussed in the Introduction, several lines of evidence have revealed a link between episodic memory and creative thinking as assessed on divergent thinking tasks (for a review, see Beaty & Schacter, 2018). However, HSAM individuals did not demonstrate enhanced performance on the AUT or on the overall measure of the CT, at least within the current task parameters. Surprisingly, the unique significant group difference showed that HSAM individuals reported lower flexibility than controls in the CT, but only when using the number of new ideas as covariate. This reinforces the idea that individuals with HSAM do not appear to possess superior divergent ability than controls, and suggests that they might be even more biased in terms of flexibility when the task requires more fantasy, such as in generating consequences for impossible situations (cf. the reduced CT-Flexibility score in HSAM subjects with the new ideas covariate). The CT has been shown to rely less on episodic memory retrieval than the AUT (Madore et al., 2015, 2016). Speculatively, individuals with HSAM might search for ideas in a fewer number of categories than controls, relying more on their episodic memory, thus resulting in less flexibility in the CT. By contrast, controls might take advantage of more flexibility in the CT, especially when controlling for new ideas. Of course, such finding needs further investigation in future studies. In addition, we failed to observe group differences on our measure of convergent thinking, the RAT. These findings are thus consistent with the hypothesis discussed in the Introduction that superior recollection of personal experiences that is characteristic of HSAM might not be specifically relevant to the constructive episodic simulation processes that support creative cognition.

As first suggested by Parker et al. (2006) and confirmed in subsequent studies (LePort et al., 2016; Santangelo et al., 2018), HSAM individuals tend to exhibit obsessive/compulsive symptoms. It may be the case that HSAM results from more efficient consolidation and retrieval of episodic details, due to the habitual rehearsal of autobiographical material. This explanation could account for the lack of observed difference between HSAM individuals and controls across creativity measures. Compulsive retrieval and recategorization of autobiographical memories may greatly enhance the ability to recall details of past experiences, while having no effect on the constructive episodic processes associated with divergent thinking.

There is a paradoxical relationship between creativity and memory-related disorders. Current research on semantic dementia indicates that, relative to healthy controls, semantic dementia patients generate fewer, less original, and less flexible responses on the AUT (Paulin et al., 2020; for a review, see Palmiero et al., 2012). While hippocampal damage has been shown to have deleterious effects on divergent thinking (Duff et al., 2013) and convergent thinking (Warren et al., 2016), there is evidence suggesting that certain forms of creativity can increase despite the progression of dementia, especially when right prefrontal cortex, posterior temporal, and parietal areas are preserved (Palmiero et al., 2012). Recent meta-analyses have noted the emergence of creativity, particularly in relation to the behavioural variant of fronto-temporal dementia (Fusi et al., 2021; Geser et al., 2021). Further clarification of the phenotypic variations associated with these cognitive disorders may provide new insight into the neural substrates which underlie episodic memory and creativity.

In summary, while HSAM participants are unequivocally superior in the recall of autobiographical events, we found no differences from control subjects in their performance on measures of creative thinking. As with any failure to observe group differences, we must exhibit some interpretive caution given our relatively modest sample size. However, our findings are notable because they appear to initially support the idea that the exceptional abilities of HSAM participants are limited to the domain of recalling autobiographical events from memory, and do not seem to extend to the constructive episodic processes involved in creative cognition. Future studies might also explore the relationship between HSAM and product-oriented approaches to creativity.

Note

1. Initially, we recruited fourteen control subjects. The number of controls was then doubled following the requested of an anonymous reviewer to enlarge the sample size of the control group. The pattern of results was similar before and after the inclusion of these additional controls.

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Data availability statement

The experiment reported here was not preregistered. The datasets generated and analysed during the current study are available from the corresponding author on reasonable request.

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