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The processes involved in mentally constructing event- and scene-based autobiographical representations

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ABSTRACT
Autobiographical experiences can be mentally constructed as generalised events or as spatial scenes. We investigated the commonalities and distinctions in using episodic and visual imagery processes to imagine autobiographical scenarios as events or scenes. Participants described personal scenarios framed as future events or spatial scenes. We analyzed the number and type of episodic details within the descriptions. To measure imagery processing, we monitored eye-movements and examined the impact of viewing a imagery disrupting stimulus (Dynamic Visual Noise; DVN) when these descriptions were made. We found that events were described with more generalised details and scenes with more perceptual details. DVN reduced the number of episodic details generated for all descriptions and eye fixation rates negatively correlated with the number of these details that were generated. This suggests that different content is used to imagine event- or scene-based experiences and imagery contributes similarly to the episodic specificity of these imaginations.

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Mental representations; imagery; mental construction; eye tracking

Introduction

Forming detailed representations of real as well as imagined autobiographical scenarios requires accessing multiple types of information related to that experience (Tulving, 2002). Research has identified that episodic processes are critical for associating together these various details within a given context to form these representations (Addis & Schacter, 2011; Moscovitch, 1992; Moscovitch, Cabeza, Winocur, & Nadel, 2016; Sheldon & Levine, 2016). Current findings suggest that the context used to situate a real or imagined autobiographical experience may change the content (details) that is brought to mind (e.g. Schacter, Addis, & Buckner, 2007; Schacter, Benoit, & Szpunar, 2017; Sheldon & Levine, 2016). Here, we compared the details used to form representations of autobiographical experiences situated within an event- or spatial-based context. We also tested the extent to which recruiting these details relied on visual imagery processes, extending the reported link between visual imagery and autobiographical memory (Rubin, 2006) to imagination.

Constructing imagined autobiographical experiences

One commonality between forming scene- and event-based imaginations is that they both rely upon episodic processes to access and integrate related details into a mental representation. There are different theories concerning the nature of this commonality. One view, the scene construction theory, proposes that scenes are the fundamental context for constructing real and imagined autobiographical representations (Hassabis & Maguire, 2007, 2009; Maguire & Hassabis, 2011). According to this theory, scenes act as the organisational tool to gather associated details of the imagined or real experiences. Another view that emerges from the constructive episodic simulation hypothesis is that scenes are not a necessary context or organisational component and other non-spatial information can guide episodic processes to gather the associated details (Roberts, Schacter, & Addis, 2018). These theories have raised the question about whether the way an imagined representation is "framed" will direct how episodic processes access details and

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subsequently change the underlying mental representations.

To answer this question, we considered how constructing imagined autobiographical scenarios framed within the context of a general event or specific scene were different. An event context is defined as an activity-based schema, which is formed from the occurrence of a similar event across multiple instances and locations (e.g. giving a conference talk; van Kesteren, Fernandez, Norris, & Hermans, 2010). The event-segmentation literature suggests that constructing an imagined scenario within an event schema or context guides an individual towards accessing generalised details describing how an underlying activity unfolds over time (Sargent et al., 2013; Zacks & Swallow, 2007; Zacks & Tversky, 2001). Thus, we predict that an event context would lead to forming an imagined scenario with predominantely generalised thematic details. Forming a scenario within a spatial context, however, is thought to recruit scene-based schemas that activate a visualised perception-based image, leading to the prediction that more perceptual details will be generated for these scenarios (Rubin & Umanath, 2014). This latter prediction is supported by autobiographical memory research that has found that recalling a familiar spatial context elicits a detail-rich and vivid memory representations (Arnold, McDermott, & Szpunar, 2011; Robin, Wynn, & Moscovitch, 2016).

We hypothesise that these differences emerge because episodic processes used to form autobiographical representations integrate different types of details together to build event- and scene-based scenarios and these differents will hold for both autobiographical memory and imagination (Schacter et al., 2007, 2017) and should present simiilarly acess. When autobiographical representations are built around event knowledge, details related to the underlying script of the activity (e.g. a script of a visit to a supermarket) will be accessed, whereas when autobiographical representations are built around a scene, perceptual details will be generated to form a visualised mental image. Some of our past work has shown that autobiographical scenarios constructed in response to a scene (e.g. coffee shop) and event (e.g. a party) cue are qualitatively different, both in terms of details used to form these representations and subjective ratings (Sheldon & Chu, 2017; Sheldon & El-Asmar, 2018), but none have directly contrasted the content contained in the constructions.

These differences between constructing event and scene imaginations are also supported by findings from neurocognitive research. For instance, there is a framework which describes separate episodic memory neural systems for retrieving and integrating thematic (event) or spatial elements of memories (Ranganath & Ritchey, 2012; Reagh & Ranganath, 2018; Ritchey, Libby, & Ranganath, 2015). There is an anterior medial temporal lobe (MTL) network that supports forming and integrating the conceptual or thematic (i.e. event) aspects of a memory, and there is a posterior MTL network that supports forming and integrating the situational (i.e. spatial) aspects of a memory. We recently extended this framework to autobiographical memory (Sheldon, Gurguryan, & Fenerci, 2019), suggesting that autobiographical experiences that are remembered or imagined within an event-based framework place demands on the network needed to gather generalised details about an event, whereas autobiographical experiences remembered or imagined within a spatial context place demands on the network needed to access perceptually-detailed information.

Visual imagery and imagining autobiographical events

Visual imagery directs how detailed autobiographical memories are retrieved (Greenberg & Knowlton, 2014; Rubin, 2006; Rubin & Umanath, 2014). Neuropsychological studies have found that individuals with damage to brain regions that support visual imagery have deficits in recalling autobiographical memories (Gardini et al., 2011; Ogden, 1993), and neuroimaging studies have reported that these visual-perceptual brain regions are recruited as a function of the vividness of a mental experience (Fulford et al., 2018). One theory is that visual imagery processes help build the “mental platform” onto which episodic processes can integrate generated details of the memory representation (for some of these views, see Greenberg & Knowlton, 2014; Rubin & Umanath, 2014; Sheldon & Levine, 2016). Whether this “mental platform” is more – or less – beneficial when constructing representations within a visualised scene or with thematic event information is not clear. There are findings that suggest a particular role of visual imagery processes in forming scene-based mental representations (Bird, Bisby, & Burgess, 2012; Maguire & Mullally, 2013), but other work suggests that imagery is foundational for constructing all forms of complex mental representations (Brewer & Pani, 1996; Greenberg & Rubin, 2003; Rubin & Umanath, 2014).

We expand on these lines of work to test if using episodic processes to construct detailed autobiographical experiences within an event or scene relies on visual imagery. To test this, we leveraged an interference stimulus that reduces access to visual imagery processes, known as Dynamic Visual Noise, DVN (Quinn & McConnell, 1996). DVN is a moving matrix of black and white squares that passively limits the recruitment of visual imagery processes without affecting executive functions, selectively interfering with the use of visual imagery processes to create complex mental representations (Anderson, Dewhurst, & Dean, 2017; Darling, Della Sala, & Logie, 2007; Dent, 2010; Kemps & Andrade, 2012; Parker & Dagnall, 2018; Sheldon, Amaral, & Levine, 2017). We also measured the recruitment visual imagery processes with eye tracking technology. Eye movement information (e.g. fixation rates) can provide insight into how visual perceptual processes function during memory and related tasks (Brandt & Stark, 1997) and measure Winternal visualised thought processes. When performing retrieval or generation tasks that do not involve "looking" at anything, researchers have found that eye fixation patterns made to a blank screen during retrieval relate to the ability to retrieve earned visual images (Johansson & Johansson, 2014; Johansson, Holsanova, Dewhurst, & Holmqvist, 2012; Johansson, Oren, & Holmqvist, 2018). This phenomenon, known as "looking at nothing", has been extended to scenarios where individuals are asked to recall or imagine complex mental representations (Laeng, Bloem, D'Ascenzo, & Tommasi, 2014). As an example, El Haj and Lenoble (2017) measured eye movements participants made to a blank screen as they imagined future or recalled past events. They reported that the number of eye fixations could discriminate between forming past and future mental representations. In other words, eye fixation data during mentally constructive tasks can indicate how much a person is generating and "inspecting" a visualised image in mind (for some related findings, Hebb, 1968; Johansson et al., 2018).

Current study

The aim of our study was two-fold. First, we wanted to compare the details (i.e., content) used to form autobiographical representations within scene- and event-based contexts. Second, we wanted to quantify the contributions of visual imagery processes to form these detailed representations. To meet these aims, we designed an experiment in which we recorded eye movements as participants made descriptions of imagined scenarios to event and scene cues under two conditions – while viewing DVN or a control stimulus. We assessed the recruitment of episodic processing by counting the number of internal (episodic) and external (non-episodic) details within the descriptions by adapting the Autobiographical Interview scoring protocol for the given imagination task (Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002). We also used a scoring metric to assess the relative use of perceptual- versus story-based internal details when forming these representations (Sheldon, Gurguryan, Madore, & Schacter, 2019). These data were used to test two predictions concerning the commonalties and distinctions in forming event-based and scene-based mental representations:

(1) If imagining event-based representations emphasises schematic/generalised information and imagining scene-based representations emphasises perceptual information, then different types of episodic (internal) details will be used to generate these representations.
(2) If visual imagery processes support generating episodic details regardless of the nature of the representation, then the DVN will similarly affect generating episodic details for imagining event- and scene-based scenarios and the rate of eye fixations made when imagining events and scenes will be predicted by the amount of episodic details.

Materials and methods

Participants

Forty young adult participants were recruited through the McGill University's participant pool or online classified advertisements. All participants were fluent in English; free from any neurological or psychological disorders, had normal or corrected-to-normal vision, and were between the ages of 18 and 35 ($M = 21$ years, $SD = 1.4$ years; 32 female). Participants gave written informed consent before completing the study and were treated in accordance with the code of ethics established by the institution. Two participants' data were removed due to incomplete collection or failure to follow instructions.

Experimental design

In a within-subjects design, participants were randomly presented with event or scene scenarios to describe in detail under two conditions (DVN and control; Figure 1). The effects of these factors (cue and condition) were examined on subjective ratings, the details used to describe the scenarios, and eye movement data.

Stimuli

Cues

Four event and four scene cues were selected from a larger set of 30 scenario cues. Each of these scenarios were assigned a rating for how much they represented a situated activity (i.e. event) or a place (i.e. scene) from a group of 90 online participants (recruited via Amazon's Mechanical Turk). These ratings were made on a sliding scale with "place" located on one end (e.g. at the "0" anchor) and "activity" located on the other end of the scale (e.g. at the "100" anchor) wherein participants moved it to an associated location for each scenario. We took the average score for each scenario and those with scores that were in the upper 50% ranking were classified as events and those with scores that were in the lower 50% ranking were classified as scenes. The four scenarios with the top ranking in each category were selected as cues in this experiment (Table 1).

Dynamic Visual Noise

Six 3-minute clips of the DVN stimuli were created using the following code (http://www.st-andrews.ac.uk/~www_sp/people/personal/jgq/). A 3-minute clip of a grey screen was used for the control condition.

Eye tracking apparatus

The cues and interference clips were presented via E-Prime experimental software, and eye movements were recorded with an EyeLink 1000 Plus (SR Research Ltd) head-mounted eye tracking system at 1000 HZ on a 24-inch monitor. We removed any eye movements that were made off the computer screen, which was our defined region of interest (8% of the data). Eye fixations were defined as gaze coordinates that were focused on one space at one time, separated by saccades.

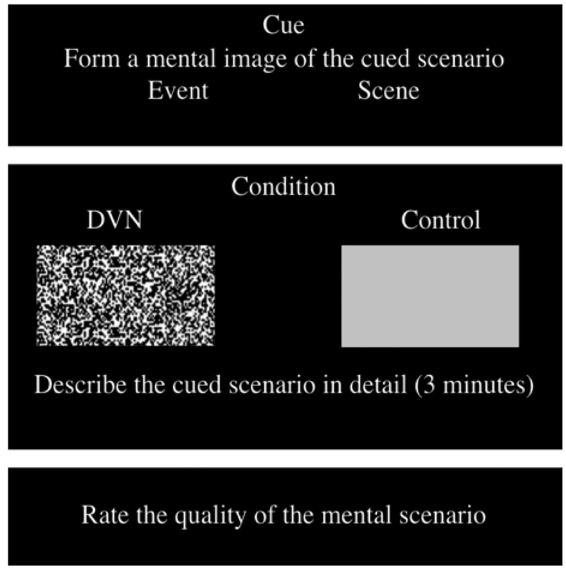

Figure 1. A schematic of the experimental design used in the study.

Procedure

Participants sat approximately 30 cm from the display with their chin and forehead resting against padded supports to reduce head movement. On the monitor in front of them, they were presented with a brief introduction to the task. They were told they were going to see a series of cues and, in response to each cue, imagine and describe the scenario in as much detail possible to the experimenter. Participants were instructed that they were to imagine an autobiographical scenario and not to recall a past memory. They were further instructed to focus straight ahead on the computer monitor while imagining and describing the scenario so that their eye movements could be monitored.

Table 1. The scenario cues used in the present experiment.

Cue type	Scenario
Event	*A Future and Plausible Award You Will Receive*
Event	*A Future and Plausible Exam You Will Write*
Event	*A Future and Plausible Wedding Reception That You Will Attend*
Event	*A Future and Plausible Family Holiday Meal*
Scene	*You Are Standing in the Aisles at a Public Library*
Scene	*You Are Lying on a White Sand Beach in a Beautiful Tropical Bay*
Scene	*You Are Standing by a Tombstone in a Cemetery*
Scene	*You are Standing by a Small Stream Somewhere Deep in a Forest*

Finally, they were informed they would view a pixelated screen or a grey screen on the monitor when describing these scenarios.

After eye movement calibration, participants completed the eight experimental trials. Each trial began with a randomly presented scene or event cue, presented as an audio recording spoken by a female and presented over headphones. The randomisation of the cues was done in a way so that each participant completed two trials for each cue type (event and scene) under the DVN and control condition. Upon hearing a cue, participants were instructed to think of the associated scenario and press a button when they were ready to describe it (access phase). After this button press, they began to describe the scenario in a much detail as possible out loud to the experimenter and were given up to three minutes (elaboration phase). If they completed their description prior to the three-minute time window, they pressed a button indicating so, and then they were given one general prompt (*Can you think of any other details?*). It was only during this description period that eye movement data were collected – from the time they pressed a button (i.e. began describing the scenario) until the end of their description – and when the randomly selected interference (DVN) or control (grey screen) video clip was presented. Our rationale to interfere with imagery during the elaboration and not access phase was based upon our predictions that visual imagery is required to form detailed representations rather than access that representation, which is known to occur at this later elaboration stage (Addis, Wong, & Schacter, 2007; Holland, Addis, & Kensinger, 2011; McCormick, St-Laurent, Ty, Valiante, & McAndrews, 2015). The descriptions were audio recorded and transcribed for later scoring. Each trial ended with the participant rating their imagined experience on seven scales (Table 2). The session ended with the participants completing a collection of questionnaires that were not included in the reported analyses [the Object Spatial Imagery Questionnaire (Blajenkova, Kozhevnikov, & Motes, 2006), the Paper Folding Test (Service, 1962), and the Plymouth Sensory Imagery Questionnaire (PSIQ; Andrade, May, Deeprose, Baugh, & Ganis, 2014)].

Table 2. The subjective ratings and the associated factors (classification) that emerged from a principle components analysis.

Classification	Rating	Question and scale
Pre-experience	Vividness	How vividly can you picture this event in your mind? 1 (I couldn't really see anything in my mind's eye) to 5 (An extremely vivid/ detailed image)
	Sense of Presence	How much did you feel as if you were experiencing this imagined scenario? 1 (I did not feel like I was there at all) to 5 (I felt strongly like I was there)
	Spatial Arrangement	How much did this scenario involve a sense of how things were arranged in space? 1 (Not at all) to 5 (A lot)
Familiarity	Past Event	Did this scenario remind you of a past personal event? 1 (This did not remind me of a past personal event at all) to 5 (This very much reminded me of a past personal event)
	Familiarity	How familiar are you with the imagined scenario?1 (Not at all) to 5 (Extremely familiar)
N/A	Perspective	How did you imagine this scenario? 1 (I was imagining it from above) to 5 (I was imagining it through my own eyes)
N/A	Activity/Place	Would you think of this scenario as an activity or place? 1 (Activity) to 3 (Both) to 5 (Place)

Description scoring

As in prior reports, the described scenarios were scored by adapting the Autobiographical Interview (AI) scoring procedure (Levine et al., 2002) to imagined experiences (for some examples see Levine et al., 2002; Madore, Gaesser, & Schacter, 2014; Madore, Szpunar, Addis, & Schacter, 2016; Sheldon et al., 2015; Sheldon, McAndrews, & Moscovitch, 2011; Vandermorris, Sheldon, Winocur, & Moscovitch, 2013). Each description was segmented into details that were then classified as either internal or external. Internal details are those that relate directly to the scenario being described and external details are those that are not specific or tangential to the scenario being described and include commentary, and semantic-based knowledge. Internal detail generation is a valid measure of recruiting episodic processes to generate content during narratives whereas external detail generation measures non-episodic process contributions. We also subcategorised the internal details generated as those that related to perception-based content and those that related to the scenario's central activity or story (Conway & Pleydell-Pearce, 2000; for a similar scoring distinction, see Sekeres et al., 2016). This was done by making use of the existing internal detail subcategories from the AI manual (see Levine et al., 2002). Internal details were classified as "perceptual" if they conveyed episodic information about sensory-perceptual elements of the generated scenario, including details about place and time (time, place, and perception details from Levine et al., 2002) and we classified internal details as "story" if they conveyed information about how the specific imagined scenario unfolded over time as well as related thoughts as this activity was being imagined (event and thought/emotion details from Levine et al., 2002).

Statistical analysis

To assess our predictions, we ran repeated measures analyses of variance (ANOVA) with condition (DVN, control) and cue (event, scene) as within-subjects factors and the average response to the examined dependent variable. When necessary, significant interaction effects were followed with post-hoc *t* tests with Tukey's correction applied. To assess prediction two, we created a Linear Mixed Effects Model with eye fixation rate modelled as a function of condition, cue and number of generated details and the interactions between these variables, with a random intercept for participant and trial. This model was estimated with the *lmer* function in R version 3.3.2 and regression coefficients and *p*-values to establish statistical significance were based on Satterthwaite approximations for denominator degrees of freedom, established using the *lme4* package (version 1.1–15; Bates, Mächler, Bolker, & Walker, 2015).

Results

Response times

We first compared the time it took participants to access the imagined scenarios. A cue (event versus scene) and condition (DVN versus control) repeated measures ANOVA on the average time to form a mental representation (access phase) indicated an effect of cue ($F(1,37) = 5.86$, $p = .29$, $\eta_p^2 = .14$) and no significant effect of condition ($F(1,37) = .28$, $p = .60$, $\eta_p^2 = .007$), a non-significant effect that was expected since the condition manipulation was made during the elaboration phase. The cue effect was because participants were quicker to generate an imagined scene ($M = 14.5$ s, $SE = 1.4$ s) than event ($M = 17.6$ s, $SE = 2.6$ s). We then ran a similar repeated measures ANOVA on the average time spent describing the scenarios (elaboration phase), which revealed an effect of cue ($F(1,37) = 4.30$, $p = .04$, $\eta_p^2 = .11$), a near significant effect of condition ($F(1,37) = 3.87$, $p = .06$, $\eta_p^2 = .10$) and no interaction between the factors ($F(1,37) = .17$, $p = .68$, $\eta_p^2 = .005$). Participants spent longer elaborating on imagined events ($M = 104.9$ s, $SE = 6.8$ s) than scenes ($M = 98.0$ s, $SE = 7.0$ s).

Subjective ratings

We reduced the collected subjective ratings using a principal component factor analysis with varimax rotation. This resulted in two distinct factors/components. One factor, which we defined as a measure of pre-experiencing, included ratings of vividness, sense of presence and spatial arrangement, with loading values of .83, .76 and .73 respectively. This factor is thought to reflect the use of imaginative processes when constructing scenarios. The second factor, which we defined as a measure of "familiarity", included ratings of scenario familiarity and reminders of past events, both with loading values of .94. We created scores for these factors by calculating the average of the associated ratings and compared these scores with separate repeated measures ANOVA with cue (event versus scene) and condition (DVN versus control) as factors. For the pre-experience scores, no effects were significant [cue, $F(1,37) = 1.01$, $p = .30$, $\eta_p^2 = .03$; condition, $F(1,37) = .16$, $p = .70$, $\eta_p^2 = .004$; interaction, $F(1,37) = .03$, $p = 0.86$, $\eta_p^2 = .001$]. For the familiarity scores, there was a main effect of cue ($F(1,37) = 5.97$, $p = .02$, $\eta_p^2 = .14$) and the other effects were non-significant [condition, $F(1,37) = .21$, $p = .65$, $\eta_p^2 = .006$; interaction, $F(1,37) = .80$, $p = .40$, $\eta_p^2 = .02$]. Participants gave higher familiarity ratings for imagined events ($M = 3.29$, $SE = .08$) than scenes ($M = 2.96$, $SE = .13$).

Detail generation

A repeated measures ANOVA on the average number of details generated with cue (event versus scene), condition (DVN versus control) and detail-type (internal versus external) as a within-subjects factor was run. There was a trend towards an effect of cue ($F(1,37) = 2.99$, $p = .09$, $\eta_p^2 = .08$), a significant effect of detail-type ($F(1,37) = 219.96$, $p < .001$, $\eta_p^2 = .90$) as the majority of details were scored as internal compared to external (mean difference = 18.5, $SE = 1.25$, $t(37) = 14.80$, $p_{\text{tukey}} < .001$) and there was also a condition effect (*F*

(1,37) = 5.47, $p = .03$, $\eta_p^2 = .13$) as more details were generated under the control than DVN condition (mean difference = 1.19, $SE = .51$, $t(37) = 2.34$, $p_{tukey} = .03$). There was no interaction between cue and detail-type ($F(1,37) = .63$, $p = .43$, $\eta_p^2 = .02$), but a significant interaction between condition and detail-type ($F(1,37) = 7.01$, $p = .01$, $\eta_p^2 = .16$). The three-way interaction effect was not significant ($F(1,37) = 1.50$, $p = .23$, $\eta_p^2 = .04$). To explore the interaction between condition and detail-type, we ran post-hoc comparisons that revealed more internal details were generated under the control condition than DVN condition (mean difference = 2.54, $SE = .72$, $t(72) = 3.53$, $p_{tukey} = .004$), yet this effect was not significant for external details (mean difference = .16, $SE = .72$, $t(72) = .22$, $p_{tukey} = .99$; Figure 2).

Next, we ran a repeated measures ANOVA on the average number of internal details generated with cue, condition and the internal-type (perceptual versus story) as within-subjects factors. There was a main effect of condition ($F(1,35) = 5.65$, $p = .02$, $\eta_p^2 = .14$), no main effect of cue ($F(1,35) = .11$, $p = .74$, $\eta_p^2 = .003$), no interaction between condition and internal-type ($F(1,35) = .41$, $p = .53$, $\eta_p^2 = .01$), yet a significant interaction between cue and internal-type ($F(1,35) = 50.85$, $p < .001$, $\eta_p^2 = .59$; Figure 3). The main effect of condition represented a greater average number of details generated under the control condition than the DVN condition (mean difference = 1.08, $SE = .46$, $t(35) = 2.38$, $p_{tukey} = .02$). Post-hoc comparisons that focused on the cue differences revealed that more perceptual details were generated for imagined scenes than events (mean difference = 3.20, $SE = .65$, $t(70) = 4.95$; $p_{tukey} < .001$) and more story details were generated for imagined events than scenes (mean difference = 3.50, $SE = 1.20$, $t(70) = 5.41$, $p_{tukey} < .001$). These comparisons also revealed a significant difference in the number of perceptual and story details generated to event cues (mean difference = 6.53, $SE = 1.20$, $t(47) = 5.44$, $p_{tukey} < .001$), such that more story details were generated than perceptual details, but an equivalent amount of these details were generated to scene cues (mean difference = .17, $SE = 1.20$, $t(47) = 1.45$, $p_{tukey} = .99$).

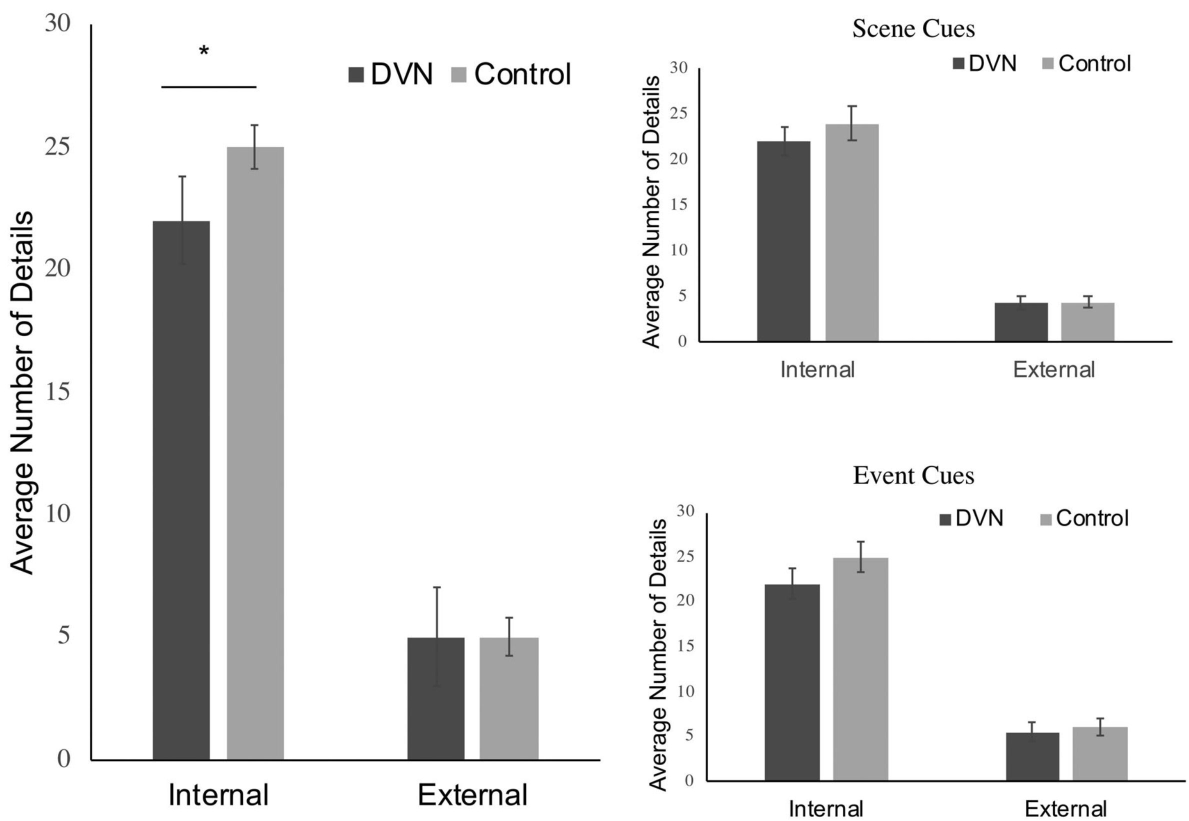

Figure 2. Left panel: The average number of details (standard error bars) generated in the DVN and control condition across the event and scene cue trials. Right panel: For illustrative purposes, the average number of details (standard error bars) generated in the DVN and control condition separated by the event and scene cue trials.

Eye movements

Due to differences in the time that participants took to describe the scenarios, we used the ratio of eye fixations made per minute (fixation rate) as the dependent variable of interest, as done in previous reports (El Haj, Nandrino, Antoine, Boucart, & Lenoble, 2017). We ran a repeated measures ANOVA with cue and condition on the average fixation rate, which resulted in a main effect of cue (F(1,36) = 6.30, p = .02, $\eta_p^2 = .15$) such that imagined events (M = 110, SE = 3.0) were associated with a higher fixation rate than scenes (M = 105, SE = 2.8). There were no other significant effects [condition, (F(1,36) = .07, p = .80, $\eta_p^2 = .002$); interaction effect, (F(1,36) = .94, p = .34, $\eta_p^2 = .03$)].

Next, we constructed a linear mixed model, fit by Restricted Maximum Likelihood, with eye fixation rate as the dependent factor and condition, cue, the number of generated internal details and the number of generated external details, and the interactions as fixed factors. Trial and participant were entered as random factors into this model to account for individual differences in performance across time. This model revealed a significant effect of cue (F(1,254) = 5.30, p = .02). The fixation rates were lower to spatial compared to the event cues ($ß$ = −2.17; SE = 1.18; t = −2.30, p = .02). Internal detail generation was also a significant predictor of eye fixation rate in this model (F(1,285) = 4.32, p = .03). As illustrated in Figure 4, internal detail generation negatively predicted eye fixation rate (β = −.32, SE = 0.15, t = −2.10, p = .03) scene and event cue conditions. Condition (F(1,255) = .59, p = .44), and external detail generation (F(1,277) = .45, p = .50) were not significant predictors, nor were any of the interaction effects.

Discussion

Mentally constructing autobiographical scenarios involves forming a complex mental representation by integrating a variety of details related to that scenario, a process that relies on both episodic and imagery processes (Brewer & Pani, 1996; Rubin, 2006; Rubin & Umanath, 2014; Sheldon et al., 2017). In the present study, we compared how episodic memory and imagery contributed to forming mental scenarios constructed within an event- or scene-based context. In a within-subjects design, a group of young healthy participants described imagined scenarios in response to cues that were events (specific activities that occur in one's life) or scenes (specific locations encountered in one's life). We measured the amount and type of episodic content within these simulations by scoring the resultant descriptions for the number of internal details (instances of specific contextualised information) and external details (instances of generalised information). We further subcategorised the internal details as those relating to the specific thematic activity (story details) or the perceptual

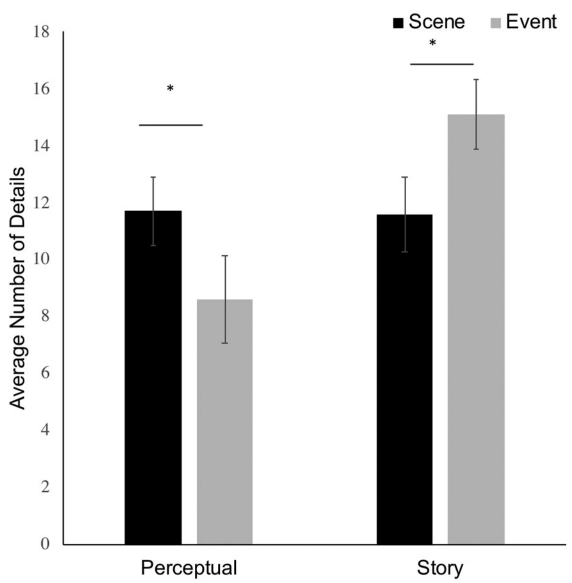

Figure 3. The average number of perceptual and story internal details (standard error bars) generated for the event and scene cue trials averaged across the control and DVN conditions.

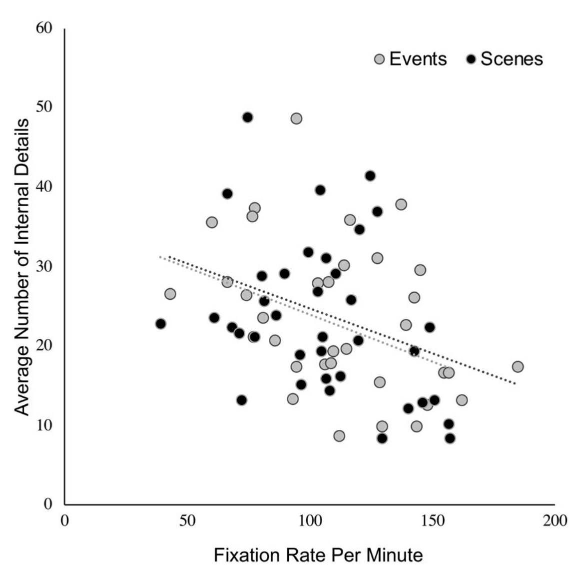

Figure 4. A scatterplot illustrating the correlation between the average number of internal details and the average fixation rate (fixations made per minute) for the event and scene cue trials.

aspects(perceptual details) of the scenario. We also measured the contribution of visual imagery to forming these simulations with two techniques. First, we manipulated whether the scenarios were described as participants were simultaneously viewing a stimulus that limited access to visual-perceptual processes (DVN). Second, we monitored participants' eye movements as they made their descriptions. From these data, we report two main findings. We found that imagined event- and scene-based scenarios were described with different episodic content, indicating that the contextual framework used to create autobiographical imaginations alters the recruited details. We also found that constructing detailed imaginations of events and scenes similarly relied upon visual imagery processes, suggesting that the contribution of the visual processes to autobiographical imagination is not driven by perceptual nature of the imagined scenarios.

Imagining autobiographical experiences within the context of a scene or event

Our first finding was that imagining autobiographical experiences in response to event versus scene cues resulted in differences in the relative recruitment of story- versus perceptually-based episodic details. If these cues are considered as serving as different forms of contexts or "scaffolds" to guide mental construction (Stark, Reagh, Yassa, & Stark, 2017), then our results suggest that the way an imagination is mentally situated will alter how episodic reconstructive processes access informational elements of a scenario to build the associated representation. Generally, this interpretation fits with a constructive account for forming past and imagined autobiographical representations that suggests that episodic processes integrate associated details during retrieval/generation to form the underlying representation (for example, see Sheldon & Levine, 2016). Moreover, the details used to form these memory representations, can be influenced by the circumstances under which it is formed (Griffith et al., 2012). Here we show circumstances (i.e. cues) that sway a mental representation to be created within a scene lead to episodic processes to construct the associated mental representation by accessing perceptual details, and imagining events leads to episodic processes to construct the representation by relying more on story-based content – how associated activities unfolded during the imagined scenario. We interpret this dissociation as support for a model of autobiographical knowledge organisation that proposes that thematic (story) and perception-based information is stored and accessed at different levels of a hierarchy (Conway, 2000). In this way, the current study expands on some of our previous reports that have shown that autobiographical memories retrieved to event versus spatial cues result in different mental experiences, with spatially-cued memories leading to more episodically-rich representations (Sheldon & Chu, 2017).

Another interesting difference that emerged from our study was that imagining autobiographical representations situated within an event resulted in greater ratings on the calculated familiarity rating score than those situated within a scene. This familiarity score was the result of a principle components analysis and we defined it as measuring a participant's rating of accessing memory-based information to create the associated imagination. Higher ratings of familiarity when imagining events versus scenes suggests that the event cues were more likely to trigger the recollection of a past experience to guide imagination than scenes. One explanation for this finding is that event activities rather than locations are a prominent method to access and organise autobiographical information (e.g. we store memories of dinner parties as a "dinner party" rather than as something that happened in a dining room), which fits with established behavioural memory research (Reiser, Black, & Abelson, 1985).

In considering our finding that scenes promoted perceptual remembering (or "pre-remembering") and events promoted accessing generalised and familiar knowledge, we turn to two main hypotheses about how detailed imagined experiences are constructed via episodic processes. One theory, the constructive episodic simulation hypothesis, suggests that episodic processes flexibly bind together details of an imagined scenario within a general context to form a representation (Schacter & Addis, 2007). Another, the scene construction hypothesis, posits that a scene-based context (i.e. a location) is the necessary scaffold to form an imagined representation (Hassabis & Maguire, 2007). On the surface, our results seem to align with the constructive episodic simulation hypothesis as this view supports the idea that different contexts or retrieval frameworks can lead to formulating different episodic representations of an imagined experience. With this said, our results are not inconsistent with scene construction theory. In fact, many of the cues used in this study overlap with those reported in a pivotal experiment showing that patients with hippocampal amnesia are impaired at describing both events and scenes in a spatially coherent manner (Hassabis & Maguire, 2007). As this view would predict that all imagined scenarios are situated within a scene-based context, it could be that both the event and scene representations generated by participants in our study began with imagining a visualised scene (e.g. both the event "holiday party" and the scene "dining room" begin with a visualised location with a dining table), yet this scene was used to gather *different* types of details depending on the cue – the reason for constructing the imagination. Although proposing different "starting" points, both theories allow for the idea that scene-based imaginations are constructed by accessing perception-based information and event-based imaginations are constructed by accessing more thematic or story-based content.

It would be interesting to examine if the reported behavioural dissociation would map onto neuroimaging findings of separate neural networks for accessing these types of episodic content (Ranganath & Ritchey, 2012; Ritchey et al., 2015; Sheldon, McAndrews, Pruessner, & Moscovitch, 2016). These findings suggest an anterior MTL network that supports accessing conceptual or event-based aspects of memories and a posterior MTL network that supports perceptually-based aspects of memories (for a discussion of these differences within the hippocampus, see Collin, Milivojevic, & Doeller, 2015; Poppenk, Evensmoen, Moscovitch, & Nadel, 2013).

Contributions from visual imagery to imagining autobiographical experiences

In addition to finding differences between the content of event and scene imaginations, we found similarity in the reliance on visual imagery processing. First, when participants described event- and scene-based imagined scenarios in the presence of the DVN, an interference stimulus known to affect visual-spatial imagery processes (Darling et al., 2007; Dent, 2010; Quinn, 2008; Quinn & McConnell, 1996), fewer internal but not external details were generated compared to a control condition. Since the DVN effect was selective to internal details, which has been linked to recruiting episodic processes to generate real or fictitious experiences (Addis, Wong, & Schacter, 2008; Levine et al., 2002; Rosenbaum et al., 2008; Sheldon et al., 2011; Steinvorth, Levine, & Corkin, 2005), this suggests that interfering with visual imagery processes impairs the ability to access and associate specific details (i.e. episodic) when building a mental representation.

The effect of the DVN on generating internal details for imagined autobiographical events follows previous work that has indicated that DVN interferes with forming complex autobiographical representations (Anderson et al., 2017; Parker & Dagnall, 2018), and work showing that forming episodically-specific mental representations relates to visual imagery ability (Greenberg & Rubin, 2003; Greenberg, Eacott, Brechin, & Rubin, 2005; Rubin & Umanath, 2014). Although some theories may have led to the prediction that disrupting visual imagery via DVN would have influenced the (perceptual) scene-based representations to a greater extent than event-based representations (e.g. the scene construction theory, see Hassabis & Maguire, 2007; Maguire & Mullally, 2013), we found a common effect of DVN on both forms of representations. We interpret this finding as evidence that forming a complex mental representation necessarily requires imagery processes, which is also supported by the collected eye-tracking data that showed a similar relationship between eye fixation rates and internal detail generation (Sheldon & Levine, 2016).

When examining the eye fixation data, we found that the number of internal but not external details used to describe both imagined events and scenes was *negatively* associated with eye fixation rate. Although this finding seemed counter to reports linking highly vivid autobiographical memory retrieval to high eye fixation rates (El Haj et al., 2017; El Haj & Lenoble, 2017), our results can be explained by the different processing demands of remembering versus imagining autobiographical scenarios. Imagining such scenarios places a greater burden on mental construction processes than remembering past scenarios that can be captured by eye movements. For example, one experiment compared past and future event generation when making concurrent eye movements and found that these movements disrupted the ability to produce internal details only when imagining the future (de Vito, Buonocore, Bonnefon, & Della Sala, 2015). Similarly, other studies have found that excessive eye movements can hamper the ability to form clear visualised images (Andrade, Kavanagh, & Baddeley, 1997) and extract information from a mental construction

(Ferreira, Apel, & Henderson, 2008). As such, we interpret the negative link between the eye fixation rate and internal detail generation as a reflection of a participant spending more time "moving around" a mental image to construct a representation than focusing on the image to extract relevant details. To this end, we suggest that eye tracking data can be used in future research to examine these different processing elements of forming complex images - searching a mental image for content versus generating the specific details of that image.

So far, we have discussed visual imagery as a unitary construct, however there is evidence to suggest there are sub-types, notably spatial and object imagery (Kosslyn, Ganis, & Thompson, 2001; Kosslyn, Thompson, Sukel, & Alpert, 2005; Thompson, Slotnick, Burrage, & Kosslyn, 2009). Object imagery refers to the ability to form perceptually-rich images of an item and spatial imagery refers to the ability to form relations between objects in the mind (Blajenkova et al., 2006). These differences in imagery raise questions about how DVN is affecting the ability to imagine autobiographical scenarios. There is some evidence to suggest that spatial and not object imagery is affected by the DVN, coming from an event simulation study (for an example, see de Vito, Buonocore, Bonnefon, & Della Sala, 2014) and one of our previous studies that indicated that DVN impairs episodic memory retrieval as a function of a spatial imagery ability (Sheldon et al., 2017). Yet, if spatial imagery represents the ability to visualise scene-based representations, this would suggest that spatial information is the necessary framework for all forms of autobiographical imagination, regardless of whether they are based on an "event" or "scene" . This proposal aligns with the scene construction theory, and suggests that participants were using a spatial context for both imagination tasks and simply using this context to access different associated details (e.g. imagining a beach scene to access details to the cue "beach", and imagining a dining room to access details to the cue "family meal"). To test for this, a future study could test how scenarios are described to similar cues that vary in the amount of spatial information (e.g. a family meal versus a dining room).

However, if spatial imagery is interpreted more broadly as representing the ability to form relations among details within a mental representation, another suggestion is that event- and scene-based imaginations both require imagery processing to associate together details within a mental representation. This interpretation would fit with research reporting that spatial imagery is a metric of the ability to maintain complex mental images, which is what is affected by DVN (Borst, Ganis, Thompson, & Kosslyn, 2012) and theories that suggest that spatial and non-spatial relations are processed similarly (e.g. see Milivojevic & Doeller, 2013) Future work could address some of these open questions, which would help refine the understanding of the link between imagination and imagery.

Closing remarks

We reported a distinction in the episodic content and a commonality in the reliance on visual imagery when imagining autobiographical experiences as events or scenes, which raises new questions about the adaptive purposes of these imaginations. There are indications that representations that are built from event/schematic information are meant to aid in tasks that require integrating commonalities across tasks (Mack, Love, & Preston, 2016; Schlichting & Preston, 2015; Sheldon et al., 2015, 2016) to benefit certain decision-making scenarios (e.g. planning complex and ambiguous events). Forming scene-based mental representations means constructing representations that are more closely matched to how a scenario is or can be experienced, which is useful for tasks that require accurate recall or navigating through known environments (Burgess, Maguire, & O'Keefe, 2002). These distinction functions maps onto another dichotomy, that between cognitive tasks that are open-ended – requiring the integration of information – and those that are close-ended - requiring more specific information pertaining to the task. Thus, we propose that testing whether event- and scene-based representations are more likely to be formed for open- versus close-ended tasks would be an interesting area of future research. From our study, we also propose a critical link between imagery and episodic content when forming both event and scene representations, which expands on a growing body of evidence linking episodic autobiographical memory to high-level imagination through the recruitment of perceptual processes (Spivey & Geng, 2001).

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