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RESEARCH REPORT

The Spatial Scaffold: The Effects of Spatial Context on Memory for Events

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Events always unfold in a spatial context, leading to the claim that it serves as a scaffold for encoding and retrieving episodic memories. The ubiquitous co-occurrence of spatial context with events may induce participants to generate a spatial context when hearing scenarios of events in which it is absent. Spatial context should also serve as an excellent cue for memory retrieval. To test these predictions, participants read event scenarios involving a highly familiar or less familiar spatial context, or person, which they were asked to imagine and remember. At recall, locations were more effective memory cues than people, and both were better when they were highly familiar. Most importantly, when no locations were specified at study, participants exhibited a spontaneous tendency to generate a spatial context for the scenarios, while rarely generating a person. Events with spatial context were remembered more vividly and described in more detail than those without. Together, the results favor the view that spatial context plays a leading role in remembering events.

Keywords: episodic memory, event memory, spatial context, scene construction, autobiographical memory

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The presence of spatial context is a defining feature of episodic memory. Because all events that we experience occur somewhere, spatial context, by necessity, is always present at the encoding of an autobiographical episode. Often it is the presence of contextual details, such as location information, at recall that is used to define the rich experience of episodic recollection (Addis & Schacter, 2011; Burgess, Maguire, & O'Keefe, 2002; Levine, Svoboda, Hay, Winocur, & Moscovitch, 2002; St-Laurent, Moscovitch, Levine, & McAndrews, 2009; Tulving, 1972, 2002).

Although spatial context is a ubiquitous feature of episodic memory for events, there is no consensus regarding its role in episodic memory representation and retrieval. Some have argued that spatial context[1] plays a fundamental role in episodic memory, even serving as the foundation upon which remembered and imagined episodes unfold (Burgess, Becker, King, & O'Keefe, 2001; Hassabis & Maguire, 2007; Maguire & Mullally, 2013; Nadel & Moscovitch, 1997; O'Keefe & Nadel, 1978). Ancient rhetoricians and modern mnemonists exploited this relation and constructed memory palaces, which enabled them to maximize the method of loci as an aid to memory retention and retrieval (Maguire & Mullally, 2013; Maguire, Valentine, Wilding, & Kapur, 2002; Roediger, 1980). However, other views of episodic memory do not attribute any special or foundational role to spatial context (Addis & Schacter, 2011; Cohen & Eichenbaum, 1993; Eichenbaum & Cohen, 2001; Schacter, 2012; Schacter, Addis, & Buckner, 2007).

If spatial context plays a role as a scaffold for episodic events, several predictions follow from this. First, if event memory is typically linked to spatial context, the location of an event may be evoked automatically during event imagination or recall. Early virtual-reality studies of memory showed that recalling detailed spatial contextual information activates many of the same neural areas as episodic memory, including the hippocampus (Burgess, Maguire, Spiers, & O'Keefe, 2001). Two recent studies using a memory paradigm set in a virtual-reality town showed that incidental spatial contextual information serves to organize memory recall, and that the retrieval of an event led to reactivation of the neuronal firing patterns corresponding to the spatial context of that event (Miller, Lazarus, Polyn, & Kahana, 2013; Miller, Neufang, et al., 2013). Köhler, Moscovitch, and Melo (2001) showed that the spatial locations of objects are encoded automatically, whereas the objects themselves are not. These studies provide evidence that spatial context is automatically encoded and evoked during recall of episodic memory, at both the cognitive and neural levels. However, it has not been shown what happens to

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[1] For the purpose of the present paper we define spatial context as a representation of a scene accompanying an episodic memory, and do not differentiate between scene representations and spatial context.

episodic memory for events when spatial context was not available at encoding. In the present study, we presented short narratives of naturalistic events with spatial context either specified in the narrative, or absent from it; when absent, it was replaced by a person. Participants were asked to imagine the event and later recall it. This allowed us to determine if context is evoked automatically in these situations.

Second, spatial cues may be more effective memory cues than other episodic elements, owing to their fundamental status in the representation of the event. Only a few studies have compared memory for imagined events, using triads of location, person, and object cues (Horner & Burgess, 2013; McLelland, Devitt, Schacter, & Addis, 2014; Szpunar, Addis, & Schacter, 2012). Thus far, there is mixed evidence about the effectiveness of different types of cues, with one study finding cue types to be equivalent (Horner & Burgess, 2013) and the other two finding that person cues were better remembered than objects or places (McLelland et al., 2014; Szpunar et al., 2012). Notably, in both studies reporting this result, the person cue was displayed at the top of the screen during event construction and was likely read first, perhaps making it more memorable (McLelland et al., 2014; Szpunar et al., 2012), while this was not the case in the study that did not find these effects (Horner & Burgess, 2013). In addition, in these studies, recall was measured by the retrieval of single items, rather than the imagined event in its entirety. Moreover, all three elements were presented on each trial, leaving no opportunity to study the spontaneous generation of elements when they were not presented. We had participants imagine events based on either a place or person cue, which always preceded the narrative, and compared recall of the content of the imagined event itself, rather than other isolated items, according to cue type.

Finally, the presence or quality of the spatial scaffold may influence the content and quality of the memories based upon it, where a stronger spatial representation is able to support richer memory for events. Several studies have shown that events imagined or recalled in more familiar settings are experienced more vividly, more clearly, and in more detail than those in less familiar or unfamiliar settings, supporting this hypothesis (Arnold, McDermott, & Szpunar, 2011; D'Argembeau & Van der Linden, 2012; de Vito, Gamboz, & Brandimonte, 2012; Robin & Moscovitch, 2014; Szpunar & McDermott, 2008). It is not clear, however, whether this effect is unique to spatial context or a general familiarity effect that applies to any element of an event. D'Argembeau and Van der Linden (2012) found that increased familiarity of the location, people, and objects in imagined events was associated with higher ratings of vividness and sense of experiencing, but they did not compare the contributions of each cue type. We compared two event elements, places and people, that both varied in familiarity, in order to separate the effects of spatial context from those general to familiarity.

In naturalistic studies of episodic memory, it is difficult to control the content or verify the accuracy of events. In order to circumvent this problem, and address the questions above, we developed a novel paradigm employing real-world location and person cues, varying in familiarity, embedded within brief narratives that participants imagined as personal episodes. The content of the events was thus more controlled than in a fully open-ended imagination study (i.e., Arnold et al., 2011; D'Argembeau & Van der Linden, 2012; de Vito et al., 2012; Robin & Moscovitch, 2014; Szpunar & McDermott, 2008), but still allowed participants to imagine and expand upon the narratives. After imagining all events, the person and place cues were used to prompt retrieval and description of the events from memory. We were able, therefore, to compare the efficacy of place and person cues in terms of recall, examine if contexts were automatically evoked when participants were asked to imagine events devoid of spatial information, and determine the separable effects of cue familiarity and the presence of spatial context on the phenomenology of recalled events.

Method

Participants

Twenty-nine people participated in the study for course credit or monetary compensation. Sample size was determined based on previous studies using similar methods (Arnold et al., 2011; de Vito et al., 2012; Robin & Moscovitch, 2014). Four participants were dropped, either due to nonfluency in English or failure to follow task instructions. The remaining 25 participants (8 male, 17 female) were fluent in English and had lived in Toronto for at least 1 year (mean age = 18.96, range = 18–23; mean years of education completed = 12.96, range = 12–16). All reported normal or corrected-to-normal hearing and vision. All participants provided informed consent prior to participating in the experiment, in accordance with the University of Toronto Office of Research Ethics.

Procedure

Prestudy questionnaire. Prior to the study, participants completed an online questionnaire providing personalized cue information for the study. Participants were asked to estimate how many times they had visited 60 landmarks in Toronto, based on the Toronto Public Places Test (Rosenbaum, Ziegler, Winocur, Grady, & Moscovitch, 2004). Landmarks that were visited 1–5 times were classified as "low familiarity," and those visited more than 10 times were considered "high familiarity," following a previous study (Robin & Moscovitch, 2014). Participants also provided the names of 10 well-known people (i.e., family members, close friends, coworkers), and the names of 10 people whom they had only met once or twice (i.e., acquaintances, teachers, doctors, neighbors). With these criteria, we attempted to match the people and place cues as closely as possible by having a set of highly familiar and less familiar cues in each. However, we acknowledge that it is possible that the highly familiar people were more familiar than the highly familiar places. If this were the case and had an impact on the results of the study, interactions between the effects of familiarity and cue type would be expected.

Encoding phase. High and low familiarity place and person cues were embedded into short stories that served as the stimuli for the study. On each trial, participants read a five-line narrative describing a brief event, were asked to imagine it as vividly as possible, and to rate it on a 1–5 vividness scale. The first line of the story situated the participant in the event and provided either a person or place from that participant's questionnaire as contextual information (e.g., "You are standing with Joanna" or "You are standing near the CN Tower"; see Figure 1A). The four following lines described a brief event, without specifying any additional details about specific locations or known individuals (e.g., "You see a boy holding a hot dog. A bird flies by and startles him. He drops the hot dog. The boy starts to cry"; Figure 1B). Once displayed, each sentence remained on the screen until the end of

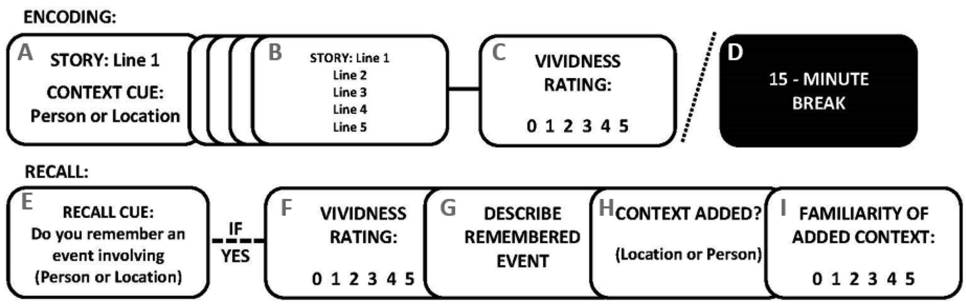

Figure 1. Schematic of the procedure of one trial of the experiment.

the story. The first sentence was displayed for 4 s, with each following sentence appearing 3 s later, and the whole story remaining on screen for an additional 6 s. The pairings of the context sentences and story sentences were interchangeable and randomly assigned. Each subject completed four practice trials followed by 20 study trials, imagining each event once.

Recall phase. After a 15-min break, during which participants completed demographic surveys, participants completed the recall portion of the experiment. Each of the person and place cues was presented again, and participants were asked to indicate if they remembered the associated event (e.g., "do you remember the event involving Joanna/the CN Tower?"; Figure 1E). If so, they rated the remembered event's vividness (1–5 scale; Figure 1F), and described what they remembered of the event and any other details that they imagined at encoding (Figure 1G). It was emphasized that they should only report details they remembered imagining and not add anything new at recall. This portion of the study was audio-recorded. For the person-cued events, participants were asked if they pictured the event occurring in a specific location, and if yes, to specify how familiar that location was on a 1–5 scale (Figure 1H and 1I). For the place-cued events, they were asked if they pictured any familiar people participating in the event and if so, to indicate familiarity on a 1–5 scale (Figure 1H and 1I). If they did not remember the associated event for a given cue, the trial was terminated. Participants completed four practice trials before beginning the section.

Description coding. The participants' recorded descriptions were transcribed and coded for the number of details remembered and described. Details were divided into narrative details that described information provided in the original event narrative, and other additional details, such as added event, place, or perceptual information. Cue information was not coded because it was provided as the recall prompt, and any additional information that was not part of the event was not coded, including semantic information, repetitions, reflections, or asides (Levine et al., 2002). Transcription and coding was done by one experimenter and verified by another.

Results

Spontaneous Addition of Spatial and Person Context When None Was Presented

Our first question was whether participants were spontaneously adding spatial contextual information to the episodes as they imagined them. Specifically, we asked whether participants were assigning spatial contextual information to person-cued events, when location was not specified, or conversely, adding particular people to place-cued events that did not contain familiar people. To determine this, after recalling an episode, participants were asked whether they added contextual information to that episode, and to rate its familiarity (Figure 1H and 1I). We compared the proportion of events to which participants added these types of information using a 2 (Cue Type: person vs. place) × 2 (Cue Familiarity: high vs. low) repeated-measures analysis of variance (ANOVA). This revealed a large main effect of cue type, $F(1, 17) = 99.16$, $p < .001$, $\eta^2 = .85$, reflecting the tendency to add location information to the majority (78%) of the remembered person-cued events, $M = 78\%$, 95% CI [68, 88], as shown in Figure 2. In contrast, participants added information about a specific person in only 16% of the place-cued events, $M = 16\%$, 95% CI [6, 26]). There was no effect of cue familiarity or a cue type by familiarity interaction on the tendency to add context information, all F values < 1, p values $> .250$.

The locations that were added to the events tended to be highly familiar, $M = 3.98$ on a 1–5 rating scale with 5 signifying *extremely familiar,* 95% CI [3.69, 4.26]. The descriptions provided during recall (Figure 1G) revealed that in the majority (90%) of trials where additional location information was described, the locations were not recombined from other trials of the study, but tended to be other familiar locations from the participants' per-

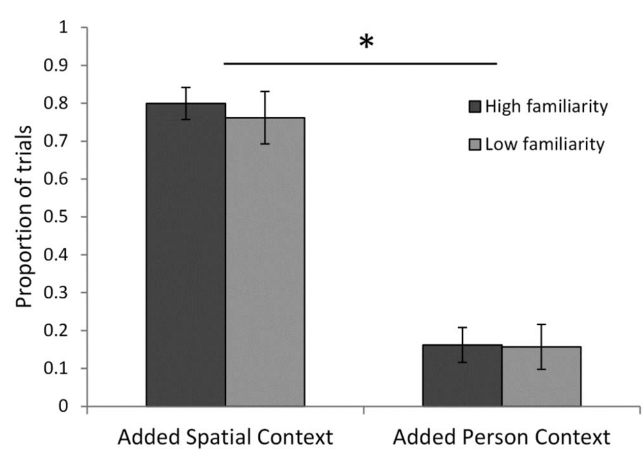

Figure 2. Proportion of trials with added contextual information. Spatial contextual information was added to the majority of person-cued events, but person information was rarely added to place-cued events, regardless of familiarity. Error bars indicate the standard error of the mean. * $p < .05$.

sonal experience (e.g., "in my room," "at the corner of Bloor St. and Spadina Ave.," "sitting outside at a café"). In some cases, the participants explained relationships between the person cue or event content and the added location information (e.g., "I knew Aaron from high school, so he and I were in our old high school," or picturing an event involving a coffee spill outside a coffee shop), though in most cases no explicit relationship or reason for the context was stated. Though people were added on only a small number of trials, they also tended to be highly familiar when added, $M = 3.96$, 95% CI [3.52, 4.40], and in the majority of cases (67%), the descriptions revealed that they were not drawn from people mentioned explicitly in scenarios from other trials.

One possibility was that participants were adding spatial locations at retrieval because they were being asked explicitly about this, although this was unlikely since the same trend was not shown with additional person information. Nonetheless, to verify this was not the case, an additional 10 participants completed a version of the experiment in which they read the stories and were asked immediately to describe everything they pictured. Even in this open-ended variation, in which participants were not asked about spatial information and there was no delayed retrieval, participants described additional place information for 81%, 95% CI [65, 97], of the person-cued events, compared with adding people in only 22%, 95% CI [8, 36], of the place-cued events, replicating the findings above and suggesting that the effect is not due to the delayed retrieval or the context-specific questions in the original study. The effect may be associated with any retrieval, immediate or delayed, or may occur at encoding (for more details, see online supplemental material).

Effects of *Nominal* (Presented) Cue Type and Cue Familiarity on Recall

Before considering the effects of generated context on memory, we compared the effects of cue type and familiarity on the number of episodes recalled with a 2 × 2 repeated-measures ANOVA. This measure was based on the number of times participants indicated that they recalled the event associated with the cue presented in the recall phase (Figure 1E). There was a significant main effect of cue type on event recall, $F(1, 24) = 8.06$, $p = .009$, $\eta^2 = .25$, see Figure 3A. More place-cued events were recalled, $M = 5.92$ out of a possible 10, 95% CI [5.15, 6.69], than person-cued events, $M = 4.52$, 95% CI [3.61, 5.43]. In addition, more events were recalled based on high familiarity cues, $M = 5.92$, 95% CI [5.19, 6.65], than low familiarity cues, $M = 4.52$, 95% CI [3.66, 5.38], main effect of familiarity, $F(1, 24) = 11.53$, $p = .002$, $\eta^2 = .33$. Familiarity effects were consistent across cue types, as shown by the nonsignificant interaction, $F(1, 24) < 1$, $p > .250$.

This effect of cue type on memory is not attributable to differences in vividness at encoding, because a 2 × 2 repeated-measures ANOVA on vividness ratings made at encoding (Figure 1C) showed that there was no difference in vividness across person- or place-cued events, $F(1, 24) = 2.16$, $p = .155$ (Figure 4). However, events involving high familiarity cues were rated as being imagined more vividly, $M = 4.13$, 95% CI [3.90, 4.36], than those involving low familiarity cues, $M = 3.23$, 95% CI [2.97, 3.50], main effect of familiarity, $F(1, 24) = 50.42$, $p < .001$, $\eta^2 = .68$, so it is possible that the familiarity effects on recall were due to the increased initial quality of the events based on high familiarity cues. There was no significant interaction between cue type and familiarity, $F(1, 24) < 1$, $p > .250$.

Comparing vividness ratings made at recall (Figure 1F), again showed only a main effect of cue familiarity, $F(1, 17) = 4.52$, $p = .048$, $\eta^2 = .21$, with remembered events based on more familiar cues rated more vivid at recall, $M = 3.82$, 95% CI [3.51, 4.12], than events based on less familiar cues, $M = 3.38$, 95% CI [2.99, 3.77]. There was no effect of cue type on vividness at recall, or any interaction between cue type and familiarity, all F values < 1, p values > 0.250. We found no effects of cue type, cue familiarity, or any interaction between the two on the number of details remembered (Figure 1G), all F values < 1, p values > 0.250. Note that the number of subjects in these analyses is 18 due to 5 participants not remembering any low familiarity-person events, and 2 not remembering any low familiarity-place events.

Effects of *Actual* Spatial and Person Context on Memory for Events

We now consider how content and quality of remembered events differs based on the presence or absence of spatial context

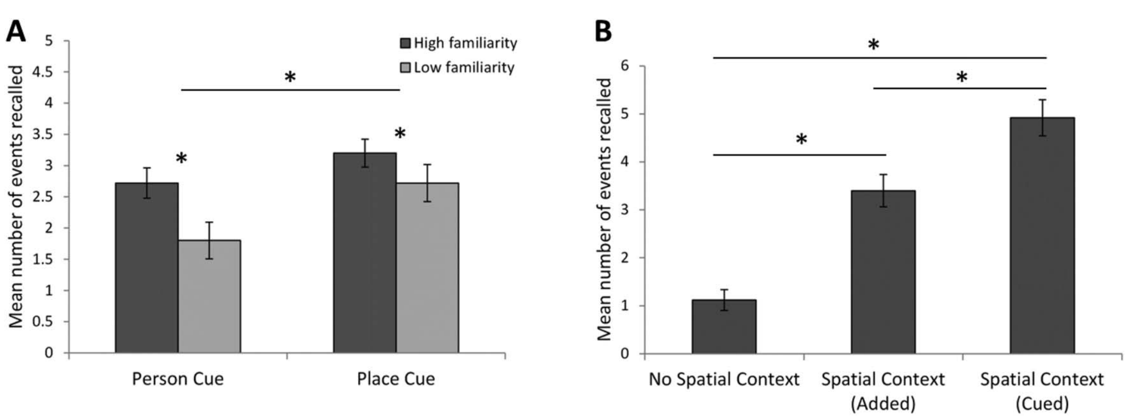

Figure 3. Mean number of events recalled after a delay according to context type and familiarity (A), and according to whether there was no spatial context, added spatial context, or cued spatial context (B). Error bars indicate the standard error of the mean. * $p < .05$.

when generated contexts are also taken into account. The results on added context (see above) highlight that comparing the events based on nominal cue type amounts, in most cases, to comparing events with a familiar person cue *and* an added highly familiar place context, against mostly events with only a place context. Considering this, it was necessary to rescore the data according to whether contextual information was added to the events or not, in order to determine, first, whether the spontaneous addition of a spatial context increased the number of events that were remembered, and, if so, to examine how the presence of person and place information affected the qualities of the remembered events. For each subject, we recategorized the data into three types: *no spatial context* (person-cued and no place information added), *spatial context-added* (person-cued with added place information), and *spatial context-cued* (place-cued and no person information added). Measures of recall, vividness, and detail were compared across these categories using Bonferroni-corrected paired *t* tests because we were specifically interested in the comparisons between the spatial context-cued condition with the no spatial context and spatial context-added conditions. We did not include the trials that were cued with place with person information added, owing to the small number of participants who had any trials in this category ($N = 12$), and because the main aim was to compare events with or without spatial context.[2]

Event recall. Using these three context categories, we compared how many events were recalled (Figure 1E) based on whether spatial context was present in the event (Figure 3B). Planned comparison paired *t* tests, using a Bonferroni-corrected alpha-level of .017 confirmed that few events were recalled in the absence of spatial context, $M = 1.12$, 95% CI [.69, 1.55], compared with when spatial context was added, $M = 3.40$, 95% CI [2.74, 4.06]; $t_{(24)} = -7.03$, $p < .001$, or provided in the initial cue, $M = 4.92$, 95% CI [4.02, 5.82]; $t_{(24)} = -8.96$, $p < .001$. There was also a significant difference between the number of events that had spatial context-added versus spatial context-cued, $t_{(24)} = -3.00$, $p = .006$. Nine subjects had no trials in the no spatial context category, reducing the sample size to $N = 16$ for subsequent comparisons.

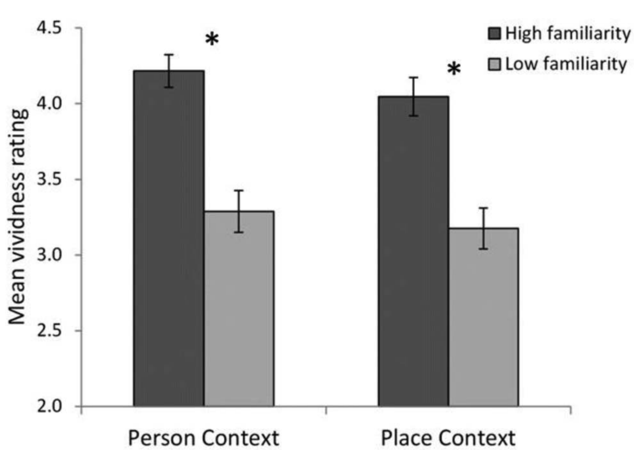

Figure 4. Mean vividness rating (1–5 scale) of events during the encoding phase, based on context type and familiarity. Error bars indicate the standard error of the mean. * $p < .05$.

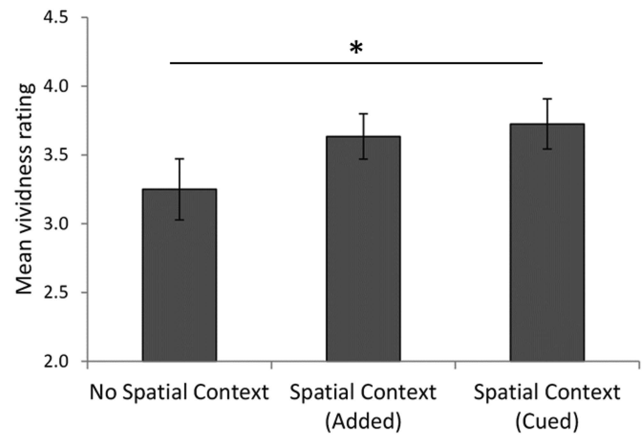

Figure 5. Mean vividness rating (1–5 scale) of remembered events, according to presence of added or cued spatial context. Error bars indicate the standard error of the mean. * $p < .05$.

Vividness ratings. Next, we considered how the presence or absence of spatial context influenced the quality of the events as measured by vividness ratings at recall (Figure 1F). Even with this reduced sample size, we found increased vividness ratings for events cued with spatial context (spatial context-cued events: $M = 3.72$, 95% CI [3.37, 4.08]) compared with those lacking it (no spatial context events: $M = 3.25$, 95% CI [2.81, 3.69]), as confirmed by a planned comparison paired *t* test ($\alpha = .025$), $t_{(15)} = -3.105$, $p = .007$, $r = .63$ (see Figure 5). When spatial context was added to person-cued events, there was no longer a significant difference in vividness for spatial-cued and person-cued events, $t_{(15)} = -.441$, $p > .250$ (spatial context-added events: $M = 3.63$, 95% CI [3.31, 3.96]).

Details remembered. Similarly, the number of remembered details described per event during recall (Figure 1G) also differed according to the presence of spatial context, as shown in Figure 6. Importantly, spatial details were omitted from these analyses, so the increase in location information in the episodes with spatial context did not contribute to the effects observed. Planned comparison paired *t* tests ($\alpha = .025$) revealed that significantly more details were remembered in the spatial context-cued events, $M = 4.84$, 95% CI [3.60, 6.07], than in the no spatial context events, $M = 3.47$, 95% CI [2.39, 4.55], $t_{(15)} = -3.095$, $p = .007$, $r = .63$. Again, when spatial context was added to the person-cued events, this difference was no longer significant (spatial context-added events: $M = 4.32$, 95% CI [2.92, 5.73], spatial context-cued vs. -added, $t_{(15)} = -1.427$, $p = .174$).

A trend toward the same difference was shown when we compared only the remembered details that were provided in the initial narratives, not including any extra details imagined by the participants, with marginally more details in the spatial context-cued events, $M = 2.90$, 95% CI [2.58, 3.22], than in the no spatial context events, $M = 2.35$, 95% CI [1.86, 2.85], $t_{(15)} = -2.367$, $p = .032$, $r = .52$, using a Bonferroni-corrected $\alpha = .025$. There

[2] Although not amenable to statistical analysis due to the small sample size, numerically this condition did not show an advantage over the spatial context-cued condition in terms of vividness rating or details remembered.

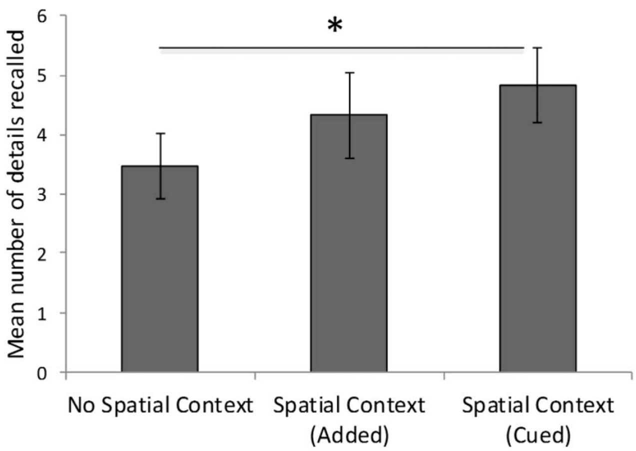

Figure 6. Mean number of details (omitting any spatial details) recalled and described per remembered event, according to presence of added or cued spatial context. Error bars indicate the standard error of the mean. * $p < .05$.

was still no difference between the spatial context-added events, $M = 2.62$, 95% CI [2.25, 3.00] and the spatial context-cued events, $t_{(15)} = -1.261$, $p = .227$. Although this just represents a subset of the total details analyzed above, any differences in number of additional details initially imagined due to the presence or absence of contextual elements are controlled for in this analysis.

Discussion

When we experience episodes in our lives, spatial context is always present. As a result, the specific contributions of spatial context to episodic memory can be difficult to elucidate, or are overlooked owing to its ubiquity. In the present study, we sought to determine the importance of spatial context in constructing and remembering events, by manipulating its presence or absence, and comparing it against another important event element, the presence of people. We found that spatial cues were more effective retrieval cues for episodes than person cues. Strikingly, we report that participants spontaneously added location information to the person-cued events when none was specified, indicating the difficulty of mentally reexperiencing an event without an accompanying spatial context, and underscoring the importance of considering the actual, as compared with the nominal, memoranda in evaluating memory.

When the events with only spatial context were compared against the person-cued events without any specified spatial context, we found an increase in the vividness and detail-richness of the events with spatial context. The events with spatial context were more detailed than the events without it, even if only non-spatial details were considered. This advantage of the spatial-cued over the person-cued condition was eliminated when a spatial context was added spontaneously to the person-cued events. A similar pattern was shown when only the details from the original narrative were considered, suggesting that the memorability of the same details differs according to the presence of accompanying spatial context. When spatial context was provided before the story was read, more of the story was later remembered than when it was not provided. Nonetheless, although there are both person and location cues when a spatial context is added spontaneously, memory performance never exceeds that observed when a spatial context alone is provided at encoding. Though effective, the spontaneously generated context may not be integrated as strongly with the event at encoding as the given context is, perhaps due to the fact that it is not initially present at the time of encoding.

Importantly, these effects cannot be attributable to the familiarity of the cues. Although the added spatial contexts tended to be highly familiar, the events in the spatially cued condition were based on high and low familiarity cues, and it was this condition that was numerically highest in terms of vividness ratings and amount of detail. These findings support the notion that the presence of a spatial context may act as a scaffold for episodic events, allowing a richer and more vivid event representation to be formed. Combined with the finding that spatial cues led to the recall of more events, and that spatial contexts were automatically evoked when not specified, this study supports views that spatial context is an important feature of imagined and remembered episodes, and can enhance the phenomenology of event memories (Burgess et al., 2001; Hassabis & Maguire, 2007; O'Keefe & Nadel, 1978; Robin & Moscovitch, 2014), though a limitation of the present study is that only person-cues were used for a comparison.

Person cues were chosen because they shared several features with spatial cues, such as real-world associations, high imageability, and variations in familiarity, which was a variable of interest in the present study. Though temporal context is frequently compared with spatial context, differing temporal contexts do not possess these features and thus were not well-suited for this design. Recent neuroimaging studies have contrasted spatial and temporal context in terms of their corresponding neural activity and connectivity (Burgess et al., 2001; Copara et al., 2014; Ekstrom, Copara, Isham, Wang, & Yonelinas, 2011; Schedlbauer, Copara, Watrous, & Ekstrom, 2014), but future studies should evaluate their relative contributions to event simulation and memory.

Thus, while we attempted to best match spatial contextual cues by choosing person cues, we acknowledge that differences still exist between these event elements, which could have contributed to the results. For example, it can be argued that since events necessarily unfold in space, the addition of spatial context is more natural than the addition of people, which are not necessary for an event. Future studies could use events where the presence of people is more central, such as social gatherings or events describing conversations, to examine if this increases the incidence of spontaneously added people. We predict that spatial context would nonetheless be added in these cases. As preliminary evidence for this, the present study featured one narrative that relied almost entirely on dialogue (receiving a phone call from a wrong number), and yet spatial context was still added in 83% of the instances in which this narrative was recalled.

This tendency of participants to add spatial context to events lacking it raises questions about the role of spatial context for episodic imagining and remembering. The scene construction hypothesis states that an underlying spatial representation is crucial for remembered and imagined events, and acts as a scaffold on which to encode memories or conjure imagined events (Hassabis & Maguire, 2007; Maguire & Mullally, 2013, see also Nadel, 2008). In the present study, in the small number of trials when participants did not generate a spatial context, they were apparently still able to imagine and remember some events devoid of any spatial context, although at the expense of the vividness and detail-richness of the event. This finding speaks against the necessity of spatial context for remembering event details, though it still supports the view that spatial context plays an important role, affecting the characteristics and memorability of an event.

One caveat to the above conclusions is that participants were asked to report whether they added a *specific* spatial context to the events that they imagined. It is possible that in the cases in which they indicated that they did not, there was a vague or rudimentary spatial context still present or they pictured some spatial information at encoding but forgot it. This interpretation leaves open the possibility that scene construction is a necessary condition for having a memory of an episodic event.

The effects of spatial context were independent of cue familiarity effects, though more familiar cues also led to increased vividness of events, regardless of cue type. These effects were shown when events were initially imagined and later recalled. These findings replicate previous studies that demonstrated that more familiar event elements lead to increased vividness and perceived detail-richness of memories and imagined events (Arnold et al., 2011; D'Argembeau & Van der Linden, 2012; de Vito et al., 2012; Robin & Moscovitch, 2014; Szpunar & McDermott, 2008). Highly familiar cues also led to greater recall of events, suggesting that increased cue familiarity makes memories more accessible, but once accessed the familiarity of the cues did not affect the number of details remembered and reported. Thus, familiarity of event elements may have an effect on the accessibility and phenomenology of the events, without affecting their content.

A limitation of the present study is that the events studied were simulated, fictional events, rather than actual autobiographical memories. One previous study of autobiographical memory reported that increased familiarity with a spatial context was associated with more detailed memories (Robin & Moscovitch, 2014), though future work should seek to directly compare different event cues in autobiographical memory in order to corroborate the present findings. This study also relates to the growing literature on memory for event simulations (Schacter, 2012; Szpunar, Addis, McLelland, & Schacter, 2013; Szpunar et al., 2012), which may confer adaptive benefits by allowing individuals to use past experiences to construct and plan for possible future situations. The results from this study suggest that placing simulations in familiar spatial locations will enhance memory and, therefore, maximize the efficacy of these simulations. Finally, the results of this study may also relate to recent studies showing that cueing participants to remember details of a previously experienced event results in more detailed subsequently remembered and imagined events (Madore, Gaesser, & Schacter, 2014; Madore & Schacter, 2015). It is possible that selectively cueing or activating a spatial context would drive this effect beyond the contributions of other types of event content, though this prediction requires further testing.

Overall, the present study provides evidence that spatial context plays an important role in remembered and imagined events, serving as a superior retrieval cue, being spontaneously added to events without it, and perhaps acting as a scaffold on which more vivid and detailed events can be constructed. Our participants seem to have intuited what mnemonists had known for centuries, namely, that spatial context provides an excellent mnemonic aid (Maguire et al., 2002; Raz et al., 2009).

References

Addis, D. R., & Schacter, D. L. (2011). The hippocampus and imagining the future: Where do we stand? *Frontiers in Human Neuroscience, 5,* 173.

Arnold, K. M., McDermott, K. B., & Szpunar, K. K. (2011). Imagining the near and far future: The role of location familiarity. *Memory & Cognition, 39,* 954–967. http://dx.doi.org/10.3758/s13421-011-0076-1

Burgess, N., Becker, S., King, J. A., & O'Keefe, J. (2001). Memory for events and their spatial context: Models and experiments. *Philosophical Transactions of the Royal Society of London Series B, Biological Sciences, 356,* 1493–1503. http://dx.doi.org/10.1098/rstb.2001.0948

Burgess, N., Maguire, E. A., & O'Keefe, J. (2002). The human hippocampus and spatial and episodic memory. *Neuron, 35,* 625–641. http://dx.doi.org/10.1016/S0896-6273(02)00830-9

Burgess, N., Maguire, E. A., Spiers, H. J., & O'Keefe, J. (2001). A temporoparietal and prefrontal network for retrieving the spatial context of lifelike events. *NeuroImage, 14,* 439–453. http://dx.doi.org/10.1006/nimg.2001.0806

Cohen, N. J., & Eichenbaum, H. (1993). *Memory, amnesia and the hippocampal system*. Cambridge, MA: MIT Press.

Copara, M. S., Hassan, A. S., Kyle, C. T., Libby, L. A., Ranganath, C., & Ekstrom, A. D. (2014). Complementary roles of human hippocampal subregions during retrieval of spatiotemporal context. *The Journal of Neuroscience, 34,* 6834–6842. http://dx.doi.org/10.1523/JNEUROSCI.5341-13.2014

D'Argembeau, A., & Van der Linden, M. (2012). Predicting the phenomenology of episodic future thoughts. *Consciousness and Cognition: An International Journal, 21,* 1198–1206. http://dx.doi.org/10.1016/j.concog.2012.05.004

de Vito, S., Gamboz, N., & Brandimonte, M. A. (2012). What differentiates episodic future thinking from complex scene imagery? *Consciousness and Cognition: An International Journal, 21,* 813–823. http://dx.doi.org/10.1016/j.concog.2012.01.013

Eichenbaum, H., & Cohen, N. J. (2001). *From conditioning to conscious recollection*. New York, NY: Oxford University Press.

Ekstrom, A. D., Copara, M. S., Isham, E. A., Wang, W. C., & Yonelinas, A. P. (2011). Dissociable networks involved in spatial and temporal order source retrieval. *NeuroImage, 56,* 1803–1813. http://dx.doi.org/10.1016/j.neuroimage.2011.02.033

Hassabis, D., & Maguire, E. A. (2007). Deconstructing episodic memory with construction. *Trends in Cognitive Sciences, 11,* 299–306. http://dx.doi.org/10.1016/j.tics.2007.05.001

Horner, A. J., & Burgess, N. (2013). The associative structure of memory for multi-element events. *Journal of Experimental Psychology: General, 142,* 1370–1383. http://dx.doi.org/10.1037/a0033626

Köhler, S., Moscovitch, M., & Melo, B. (2001). Episodic memory for object location versus episodic memory for object identity: Do they rely on distinct encoding processes? *Memory & Cognition, 29,* 948–959. http://dx.doi.org/10.3758/BF03195757

Levine, B., Svoboda, E., Hay, J. F., Winocur, G., & Moscovitch, M. (2002). Aging and autobiographical memory: Dissociating episodic from semantic retrieval. *Psychology and Aging, 17,* 677–689. http://dx.doi.org/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, and Cognition, 40,* 609–622. http://dx.doi.org/10.1037/a0034885

Madore, K. P., & Schacter, D. L. (2015). Remembering the past and imagining the future: Selective effects of an episodic specificity induction on detail generation. *Quarterly Journal of Experimental Psychol-*

ogy. Advance online publication. http://dx.doi.org/10.1080/17470218.2014.999097

Maguire, E. A., & Mullally, S. L. (2013). The hippocampus: A manifesto for change. *Journal of Experimental Psychology: General, 142,* 1180–1189. http://dx.doi.org/10.1037/a0033650

Maguire, E. A., Valentine, E. R., Wilding, J. M., & Kapur, N. (2002). Routes to remembering: The brains behind superior memory. *Nature Neuroscience, 6,* 90–95. http://dx.doi.org/10.1038/nn988

McLelland, V. C., Devitt, A. L., Schacter, D. L., & Addis, D. R. (2014). Making the future memorable: The phenomenology of remembered future events. *Memory*. Advance online publication. http://dx.doi.org/10.1080/09658211.2014972960

Miller, J. F., Lazarus, E. M., Polyn, S. M., & Kahana, M. J. (2013). Spatial clustering during memory search. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 39,* 773–781. http://dx.doi.org/10.1037/a0029684

Miller, J. F., Neufang, M., Solway, A., Brandt, A., Trippel, M., Mader, I., . . . Schulze-Bonhage, A. (2013). Neural activity in human hippocampal formation reveals the spatial context of retrieved memories. *Science, 342,* 1111–1114. http://dx.doi.org/10.1126/science.1244056

Nadel, L., & Moscovitch, M. (1997). Memory consolidation, retrograde amnesia and the hippocampal complex. *Current Opinion in Neurobiology, 7,* 217–227. http://dx.doi.org/10.1016/S0959-4388(97)80010-4

Nadel, L. (2008). Hippocampus and context revisited. In S. Mizumori (Ed.), *Hippocampal place fields: Relevance to learning and memory* (pp. 3–15). NY: Oxford: Oxford University Press.

O'Keefe, J., & Nadel, L. (1978). *The hippocampus as a cognitive map*. New York, NY: Oxford University Press.

Raz, A., Packard, M. G., Alexander, G. M., Buhle, J. T., Zhu, H., Yu, S., & Peterson, B. S. (2009). A slice of pi: An exploratory neuroimaging study of digit encoding and retrieval in a superior memorist. *Neurocase, 15,* 361–372. http://dx.doi.org/10.1080/13554790902776896

Robin, J., & Moscovitch, M. (2014). The effects of spatial contextual familiarity on remembered scenes, episodic memories, and imagined future events. *Journal of Experimental Psychology: Learning, Memory, and Cognition, 40,* 459–475. http://dx.doi.org/10.1037/a0034886

Roediger, H. (1980). The effectiveness of four mnemonics in ordering recall. *Journal of Experimental Psychology: Human Learning and Memory, 6,* 558–567. http://dx.doi.org/10.1037/0278-7393.6.5.558

Rosenbaum, R. S., Ziegler, M., Winocur, G., Grady, C. L., & Moscovitch, M. (2004). "I have often walked down this street before": fMRI studies on the hippocampus and other structures during mental navigation of an old environment. *Hippocampus, 14,* 826–835. http://dx.doi.org/10.1002/hipo.10218

Schacter, D. L. (2012). Adaptive constructive processes and the future of memory. *American Psychologist, 67,* 603–613. http://dx.doi.org/10.1037/a0029869

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. http://dx.doi.org/10.1038/nrn2213

Schedlbauer, A. M., Copara, M. S., Watrous, A. J., & Ekstrom, A. D. (2014). Multiple interacting brain areas underlie successful spatiotemporal memory retrieval in humans. *Scientific Reports, 4,* 6431. http://dx.doi.org/10.1038/srep06431

St-Laurent, M., Moscovitch, M., Levine, B., & McAndrews, M. P. (2009). Determinants of autobiographical memory in patients with unilateral temporal lobe epilepsy or excisions. *Neuropsychologia, 47,* 2211–2221. http://dx.doi.org/10.1016/j.neuropsychologia.2009.01.032

Szpunar, K. K., Addis, D. R. D., McLelland, V. C., & Schacter, D. L. D. (2013). Memories of the future: New insights into the adaptive value of episodic memory. *Frontiers in Behavioral Neuroscience, 7,* 47.

Szpunar, K. K., Addis, D. R., & Schacter, D. L. (2012). Memory for emotional simulations: Remembering a rosy future. *Psychological Science, 23,* 24–29. http://dx.doi.org/10.1177/0956797611422237

Szpunar, K. K., & McDermott, K. B. (2008). Episodic future thought and its relation to remembering: Evidence from ratings of subjective experience. *Consciousness and Cognition: An International Journal, 17,* 330–334. http://dx.doi.org/10.1016/j.concog.2007.04.006

Tulving, E. (1972). Episodic and semantic memory. In E. Tulving & W. Donaldson (Eds.), *Organization of memory* (pp. 382–402). New York, NY: Academic Press.

Tulving, E. (2002). Episodic memory: From mind to brain. *Annual Review of Psychology, 53,* 1–25. http://dx.doi.org/10.1146/annurev.psych.53.100901.135114

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