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ORIGINAL ARTICLE

The many routes of mental navigation: contrasting the effects of a detailed and gist retrieval approach on using and forming spatial representations

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Abstract Navigated routes can be recalled by remembering a schematic layout or with additional sensory and perceptual details, engaging episodic memory processes. In this study, we contrasted the effects of these remembering approaches on retrieving real-world navigated routes, the impact on flexibly using familiar route information and on learning new spatial representations. In a within-subjects design, participants were oriented to recall familiar routes under two remembering conditions—a detail condition that promoted episodic memory processes and a gist condition in which routes were recalled via schematic processes. In each condition, participants performed two subsequent navigation tasks. They first described solutions to navigation problems that involved the recalled familiar route (e.g., navigating around a road block or to a new destination) and then learned and recalled a route within a novel spatial environment. All navigation descriptions were scored for the number of spatial references, entities, and sensory descriptions. We report the following findings. First, when describing the familiar routes, more details were generated in the detail condition, but a higher proportion of these details were spatial references in the gist condition. Route descriptions in the gist condition also relied more on egocentric spatial representations than in the detail condition. Next, when solving navigation problems in the familiar environment, solution routes were described with more details in the detail condition and deviated less from the familiar route than in the gist condition. Finally, the detail condition led to the preferential encoding of entity and sensory descriptive details of new spatial representations. These findings suggest that activating episodic processes at retrieval has distinct effects on how familiar information can be flexibly used and how new spatial representations are formed.

Introduction

The routes that we have traveled in our lives can be remembered in different ways. We can recall a navigated route by retrieving a simple 'map-like' or schematic representation, bringing to mind basic directions and established landmarks, or we can recall a route by bringing to mind a rich and vivid mental image of the navigated spatial environment, remembering both the path taken and the accompanying sensory and perceptual details (Burgess, 2008; Hirshhorn, Newman, & Moscovitch, 2011; Moscovitch et al., 2005). These two ways of route recall represent gist versus detailed approaches to retrieval that depend on distinct cognitive mechanisms (for some discussions about these forms of remembering, see Conway & Pleydell-Pearce, 2000; Henkel, 2014; Koutstaal & Cavendish, 2006). While gist retrieval relies more strongly on semantic memory processes to recall well-established information and general knowledge, detailed retrieval relies more heavily on episodic memory processes mediated by the hippocampus to recall contextually specific details, particularly for spatial memories (Hirsh, 1974; Rosenbaum, Gao, Richards, Black, & Moscovitch, 2005). Here, we investigate whether these different forms of retrieval affect the way spatial navigation representations are used and formed.

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Different approaches to remembering

Research has indicated that the tendency to use a gist versus detailed approach to remembering is affected by several stable factors, such as the remoteness of a recovered memory (Lux, Bindrich, Markowitsch, & Fink, 2015), the age of the individual remembering (Koutstaal, Schacter, Galluccio, & Stofer, 1999) and the presence of an emotional disorder (Williams et al., 1996; Williams & Scott, 1988). Interestingly, there is also evidence that these approaches to remembering are affected by transient factors present at retrieval. In one study, participants were asked to describe photographs under two conditions—a condition that promoted detailed retrieval by asking participants to describe specific details of a set of photographs and another condition that promoted gist retrieval by asking participants to describe the general concept of a set of photographs. When participants were later asked to recall past autobiographical events, participants in the detailed retrieval condition recalled more episodic (i.e., specific) content from their autobiographical memories than those in the gist retrieval condition (Rudoy, Weintraub, & Paller, 2009). This result was taken as evidence that altering one's 'orientation state' at retrieval can affect the way past information is remembered. In line, other investigations have found that altering the cognitive demands of a given task can affect performance on a subsequent remembering measure. For example, studies have found that if participants are given a cognitive task that involves episodic memory processing and then are asked to recall information learned prior to that task, the learned information will be recalled with more episodic content and specific details than if the participants were first given a task that did not involve episodic memory (Henkel, 2014; Koutstaal & Cavendish, 2006).

A recent series of experiments manipulated the likelihood of taking a detailed or gist approach to remembering by providing participants with a brief training session that encouraged the use of episodic memory processes for retrieval (i.e., recalling specific details from events) or encouraged the engagement of generalized, non-episodic processes for retrieval (i.e., recalling the general impressions of events). The effect of this training manipulation on several subsequent tasks has been examined. A common finding is that a detailed compared to a gist remembering approach that is induced via training enhances performance on tasks that require retrieving episodically detailed mental representations, including autobiographical memory retrieval, future imagination tasks and social problem solving (Jing, Madore, & Schacter, 2016; Madore, Addis, & Schacter, 2015; Madore, Gaesser, & Schacter, 2014; Madore, Jing, & Schacter, 2016; Madore & Schacter, 2014, 2016; Madore, Szpunar, Addis, & Schacter, 2016). Generally, these findings are in line with embodied cognition (Barsalou, 2008, 2010) that states that mentally simulating scenarios can benefit cognitive tasks. More specifically, these findings are in line with the constructive episodic simulation hypothesis (Schacter & Addis, 2007) that states that recruiting episodic memory processes allows for retrieved information to be used in a flexible and adaptive way such that recovered details can be recombined to create novel mental representations of scenes and scenarios. These new mental scenes and scenarios can benefit complex cognitive tasks by serving as a platform to guide goal-directed thoughts and behaviors.

Spatial navigation

Episodic memory processes are fundamental to spatial navigation tasks when detailed representations are required; however, episodic processes may not be necessary when spatial navigation can be done by retrieving schematic environmental representations (Burgess, Maguire, & O'Keefe, 2002; Maguire, Intraub, & Mullally, 2016; Moscovitch, Nadel, Winocur, Gilboa, & Rosenbaum, 2006; Spiers & Maguire, 2007). Support for this dissociation comes from findings that patients with selective impairment in episodic memory from hippocampal damage can successfully navigate old and familiar environments at a schematic level but are impaired at recalling episodic or fine-grained details of these routes (Herdman, Calarco, Moscovitch, Hirshhorn, & Rosenbaum, 2015; Maguire, Nannery, & Spiers, 2006; Rosenbaum, Cassidy, & Herdman, 2015; Teng & Squire, 1999). For example, a recent study found that patients with hippocampal amnesia were not impaired when tested with schematic spatial navigation tasks that assessed real-world route information, such as drawing a map of a familiar environment or providing basic directions to follow a well-learned route. However, these patients were impaired in describing details from these familiar routes, particularly the routes' sensory and perceptual details (Herdman et al., 2015). Research has also found that patients with hippocampal amnesia are unable to imagine and coherently describe real-world but not experienced scenes in detail (e.g., a tropical beach, Hassabis, Kumaran, Vann, & Maguire, 2007) and neuroimaging studies have confirmed a role for the hippocampus in updating or constructing new spatial representations (Hassabis & Maguire, 2009; Maguire & Hassabis, 2011; Maguire & Mullally, 2013; Mullally, Vargha-Khadem, & Maguire, 2014). These results can be explained by the hypothesis that hippocampally mediated episodic processes flexibly update schematic spatial representations with specific sensory and contextual details (Maguire & Mullally, 2013; Moscovitch, Cabeza, Winocur, & Nadel, 2016; Rubin, Watson, Duff, & Cohen, 2014;

Schacter et al., 2012; Sheldon & Levine, 2016). More specifically, detailed remembering provides more flexibility to mentally explore environments because hippocampally mediated processes update static egocentric spatial representations with specific details from contextually rich allocentric representations of space (Brunye, Rapp, & Taylor, 2008). To date, the specific effects of recruiting such episodic process during mental navigation have yet to be fully explored in healthy populations.

The current study: aims and predictions

The overall objective of this study was to examine the benefit of using a detailed remembering approach—one that recruits episodic memory processes—on the ability to simulate mentally navigated routes. There were two main study aims. First, we aimed to establish the difference in how navigated routes are recalled when taking a detailed or a gist remembering approach. Based on reports that accessing detailed mental simulations recruits sensory–perceptual processes (Barsalou, 2008, 2010), we predicted that a detailed remembering approach would preferentially affect retrieving sensory and perceptual details but not spatial-schematic details of navigated routes. We also predicted that familiar routes described when using a gist remembering approach would depend more on static, egocentric spatial representations. To meet this aim, we compared the way participants described familiar routes from their daily lives using a detailed or gist remembering approach. Our second study aim was to test how a detailed remembering approach influenced the novel use of familiar spatial information and the ability to learn new spatial layouts. Based on the constructive episodic simulation hypothesis (Maguire et al., 2016; Maguire & Mullally, 2013; Moscovitch et al., 2016; Rubin et al., 2014; Schacter et al., 2012; Sheldon & Levine, 2016), we hypothesized that if using familiar spatial information in new ways requires episodic processes to update spatial representations, then a detailed remembering approach would result in more efficient use of recalled information than gist remembering. We also hypothesized that if promoting episodic processes during detailed remembering affects subsequent learning by targeting sensory–perceptual processes (Barsalou, 2008, 2010), then a detailed remembering approach would benefit the ability to learn such details of a new route. To meet this second aim, we contrasted the effects of the different remembering approaches on two subsequent navigation tasks: one that required participants to solve a 'navigation problem' by creating new routes within their recalled familiar environments (i.e., flexibly using retrieved information) and another that required participants to learn and recall the details of a new navigation route.

Method

Participants

Twenty-eight young healthy adults were recruited through advertisements posted throughout McGill University and through the University's Psychology Participant Pool. All participants were fluent in English, had no history of neurological conditions or disorders and had been living in Montreal for at least one year (e.g., they were familiar with the tested spatial environment). Four participants were excluded from analyses as they failed to appropriately follow the instructions, thus, the analyzed sample included 24 participants (13 females) between 18 and 24 years of age (mean age 22.25; SD 3.08; mean education 16.67; SD 2.50). All participants gave written consent before completing each study session and were treated in accordance with the code of ethics established by the institution.

Materials and procedure

Materials

The stimuli for this experiment consisted of familiar walking routes that were defined for each participant (familiar routes) and videos of novel walking routes (novel routes).

Familiar routes To create the familiar route stimuli, participants completed a short questionnaire before the in-laboratory testing session. Participants submitted the start and end location (with street intersections; e.g., start location: "my house on Parc Avenue and Villeneuve Street"; end location: "the gym on Mont Royal Avenue and St Urbain Street") of four familiar walking routes. The participants were instructed to choose routes that lasted approximately 10 min and that they habitually traveled by foot. For each route, the participants indicated the reason for traveling the route (e.g., "to take a spin class"). Participants were also instructed to select routes that they would be comfortable discussing in detail.

From these four routes, the experimenter selected the two routes that were most closely matched in length and estimated number of turns to serve as stimuli in the experiment. Length and turn estimates were established by plotting the route between the given start and end points via Google Maps and using the suggested walking route to extract length and number of turns.

Novel routes Two first-person perspective videos of walking routes were recorded on a GoPro HERO camera by the experimenter (Fig. 1). The videos depicted routes

Fig. 1 A screenshot from one of the videos used as stimuli in the novel route task. All videos were shot with a GoPro Hero and taken from a first-person perspective

that took place in an environment unfamiliar to the participants (i.e., not around the University campus). The videos were equal in length (350 m) and time (3:48 min) and each included one turn. Both routes were similar in environmental complexity but distinct in detail as they were filmed in the same neighborhood, at the same time of day but the filmed routes did not overlap.

Procedure

Participants completed two experimental sessions—a gist and detail condition—that took place five to ten days apart (mean days apart 6.38; SD 1.31). The order of these sessions was counterbalanced across participants. All task instructions were displayed on a computer monitor using E Prime software. Both sessions included three tasks (described below) and the only difference between the conditions occurring during the initial familiar route description task (see Fig. 2 for a schematic of the experimental design).

Familiar route description task The route description instructions for the detail and gist condition were designed to facilitate a detailed versus gist remembering approach, respectively. These instructions were based on those used by Hirshhorn et al. (2011). For both conditions, participants were presented with the start and end of one of their familiar routes and asked to describe that route as they imagined navigating it (i.e., from an egocentric perspective). Different routes were used for each condition.

In the detail condition, they were instructed to recall route directions (i.e., navigating from the start to end locations) while recalling descriptive details, emotions, habits, etc. They were told to describe the route in as much detail as possible by visualizing the route in their mind, imagining what things looked like and where things were in relation to each other. Examples of route details were given to the participants.

In the gist condition, they were instructed to recall directions for the given familiar route without such descriptive details. They were told to provide the most basic directions (north, west, straight, left, etc.) needed to follow the route and were instructed to focus on the directions taken during the route and major turns and stops.

For both conditions, they were told to speak as naturally as possible and there was no time limit for their route descriptions. After describing each the route, participants rated their subjective experience on several scales, including how vividly they imagined the route from 1 (low) to 5 (high), their sense of presence while imagining the route from 1 (not at all) to 5 (fully immersed), and to estimate the route's approximate distance (in meters).

Navigation problem tasks Road block problem: Participants were presented with the same start and end location of the described familiar route but were additionally given the name of a road along that route that was blocked—making the familiar path to the endpoint no longer accessible (based on Rosenbaum et al., 2005). The road that was blocked off was the closest major street to the starting position of the familiar route. Participants were told to imagine and describe the most direct route to get to the same endpoint of their familiar route while detouring around the road block. After describing the new route, participants rated their imagined route for vividness (1–5), sense of presence (1–5), and estimated the route's approximate distance (in meters).

New location problem: Participants were presented again with the start and end of the familiar route. For this task, they were also given a scenario designed by the experimenter that would require the participant to find a new end location that would fulfill the same goal associated

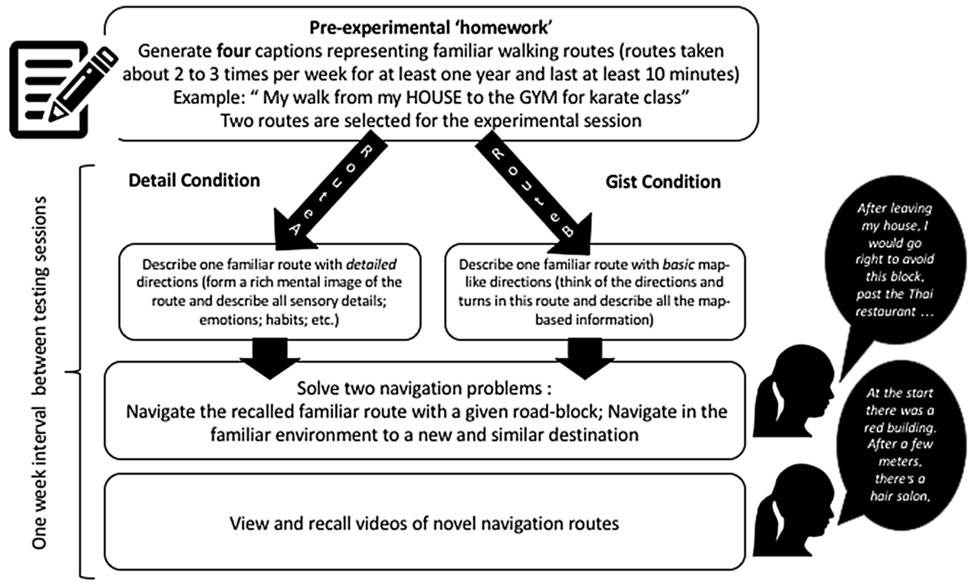


Fig. 2 A schematic of the experimental design

with the familiar route. (e.g., "the gym you typically walk to is closed, find a new work-out location"). Participants were told this new route should be approximately the same distance as the familiar route. They were asked to press "1" when they had a new location in mind and then describe the imagined new route from their original start location to the new end location. As in the road block problem, participants gave ratings for vividness, sense of presence, and estimated the route's approximate distance.

The instructions for these two problems did not differ between the gist and detail conditions and no time limit was imposed on the route descriptions.

Novel route encoding task Participants watched a video of a route navigated in a novel spatial environment from a first-person perspective. They were instructed to pay attention to all details in the video. After a short 3-min distraction task, participants were asked to describe the video from start to finish, including all details they could remember. No time limit for describing these routes was given. Next, participants rated the imagined route's vividness, sense of their own presence and their sense of familiarity with the route all on scales from 1 (low) to 5 (high). They also estimated the route's approximate distance (in meters) and time. Task instructions were identical for the gist and detail condition and different videos were used for each condition.

Scoring procedure

Route description details All route descriptions were audio-recorded and transcribed for scoring. Two trained scorers divided each description into segments of discrete units of information and then, following the scoring procedures outlined by (Hassabis et al., 2007) and updated by (Herdman et al., 2015), classified these segments as:

- Spatial references (SPA): Descriptions concerning the participant's location in space along the imagined route and relative positions of entities described in relation to the participant or other objects (e.g., "The coffee shop would be to the left"; "I would turn right in front of the movie theatre").
- Entities present (EP): Descriptions of distinct items, such as landmarks, people or objects (e.g., "There is a school").
- Sensory descriptions (SD): Descriptive statements about the sensory or perceptual quality of an entity (e.g., "There would be a bright light"; "I often hear a very *loud* siren"; "I would pass by a red brick building") or general conditions when imagining the route (e.g., "It is very humid").
- Thought, emotion, action (TEA): Descriptive information that are extraneous to the described route, including how one was feeling or thinking (e.g., "I love walking in the Fall"; "Often I will plan what I will do with my day as I walk this route").

For each task, the number of spatial references (SPA), entities present (EP) and sensory descriptions (SD) that were used to describe a route was tallied. Scores for these two problem tasks were averaged for each participant to create one metric of navigation problem performance. Based on prior work (Herdman et al., 2015; Rosenbaum et al. 2015), the number of SPA was used as a metric for forming schematic spatial representations and the number of EP and SD was used as a metric for recruiting episodic memory processes when forming spatial representations. The proportion of SPA details was calculated to assess the reliance on schematic navigation representations (Herdman et al., 2015). TEA details were not considered in the analysis as they are external to the route description task (i.e., these details do not reflect the recruitment of spatial representations).

Egocentric spatial reference estimates For the familiar route descriptions, we tallied the number of self-references that were included as a metric of the reliance on egocentric spatial representations by following a published scoring protocol (Kurczek et al., 2015). Self-references were defined as first person singular (“I”, “me”) as well as first person plural (“we”, “us”, “our”) pronouns. Any repetitions of self-references or those that were not about the route were not counted (e.g., “I can’t remember”). The proportion of self-references to the overall word count used to describe the route was calculated to account for differences in output among route descriptions.

Route efficiency estimates For the route description and navigation problem tasks, we collected estimates of the true length of the routes described. Two coders read each transcription and mapped out the route on Google maps to extract precise distances in meters (Fig. 3). From these estimates, we created ‘distance deviation estimates’ of the solution routes described for the navigation problems by subtracting the length of the familiar routes (i.e., description task) from the length of the solution routes. One participant’s route distances could not be estimated from the transcriptions.

Statistical analysis

For all tasks (route description, navigation problem and novel route), we analyzed the within-subject effect of condition (detail versus gist) on the subjective ratings associated with the mentally navigated route using a repeated measures MANOVA and on the number and type of details used to describe the routes using a repeated measures ANOVA. We also tested the effect of condition on the proportion of details that were SPA via ANOVAs. All significant effects were followed with post hoc comparisons.

For the familiar route description task, we assessed condition difference in the proportion of self-references via a paired *t* test. For the navigation problem task, we assessed condition differences in route efficiency estimates with both repeated measures ANOVA and linear regressions models for each condition. For the novel route task, we ran a series of Pearson correlations between the generated number and the type of details and those generated during the familiar route description task to investigate condition effects on the interplay between forming familiar and new spatial representations.

Results

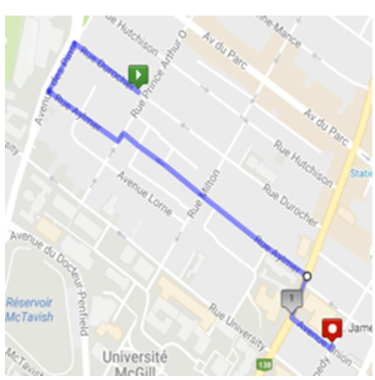
Familiar route descriptions

Subjective ratings

The repeated measures MANOVA test with condition as a within-subject factors and the subjective ratings (sense of presence and vividness) as dependent variables revealed a significant interaction effect [$F(3, 21) = 3.78$, $p = 0.04$; $\eta_p^2 = 0.26$]. Subsequent univariate tests indicated that there was no condition difference for vividness [$F(1, 23) = 2.24$, $p = 0.15$, $\eta_p^2 = 0.09$], but a significant difference between the conditions for sense of presence [$F(1, 23) = 4.60$, $p = 0.04$, $\eta_p^2 = 0.17$]. As indicated in Table 1, familiar routes described in the detail condition were rated with a greater sense of presence than those described in the gist condition.

Route description details

The repeated measures ANOVA with condition (2: gist vs detail) and detail type (3: SPA vs EP vs SD) as within-subject factors resulted in significant main effects of condition [$F(1, 23) = 22.77$, $p < 0.001$, $\eta_p^2 = 0.50$] and detail [$F(2,$



“Ok well I’ll have to come out of my office which is just off on Durocher. There is a flower shop on the corner. I would past this flower shop on my right and go up Durocher instead of going down, towards the water. I would walk up for a few blocks, past a red house and a bike stand, and then turn right on to Pin. Once I was on Pin, I would walk on the right sidewalk, which is cracked, and then turn down Aylmer. On Alymer, there are a lot of old brick houses. I would past a row of these, and then a little corner shop a block later. I would keep going down Alymer, crossing Milton street and passing the Pizza shop which smells so good! Then, I would hit Sherbrooke. There is a big office building here that is very tall. Then I’ll just continue the same way. So turn right on Sherbrooke, try to cross the street at the stoplight but it is always so busy and then turn left on union to the coffee shop.”

Fig. 3 A sample narrative of a response given to a road block navigating problem (*right side*) and mapped out route via Google Maps to achieve an estimated distance (*left side*)

Table 1 The average ratings and estimated lengths of the familiar route description task for each condition (gist and detail)

Rating	Condition	Mean	SE
Sense of presence*	Gist	3.42	0.23
	Detail	3.92	0.16
Vividness	Gist	3.75	0.2
	Detail	4.0	0.13
Length estimate (*M*)	Gist	870	92
	Detail	943	136

* A difference between conditions at $p < 0.05$

Table 2 The average number of details classified as a spatial reference, entity or sensory description that was generated for the familiar route description task for each condition (gist and detail)

Detail	Condition	Mean	SE
Spatial reference (SPA)*	Gist	13.25	1.47
	Detail	21.79	1.99
Entities present (EP)*	Gist	9.79	1.62
	Detail	28.04	3.68
Sensory description (SD)*	Gist	1.71	0.55
	Detail	9.17	1.76

* A difference between conditions at $p < 0.05$

46) = 72.68, $p < 0.001$, $\eta_p^2 = 0.76$] such that more details were generated for routes described in the detail condition (mean 59.0, SE 7.0) compared to the gist condition (mean 25.0, SE 3.4; $p < 0.001$, $d = 0.97$) and more SPA (mean 17.5, $E = 1.5$) and EP details (mean 18.9, SE 2.1) were generated than SD details (mean 5.4, SE 0.9; $p < 0.001$). There was also a significant interaction between these factors [$F(2, 46) = 13.54, p < 0.001, \eta_p^2 = 0.37$]. Within the detail condition, pair-wise comparisons indicated significantly fewer SD details compared to the number of SPA and EP details were generated ($p < 0.001$), but no significant difference between the number of SPA and EP details ($p = 0.06$). Within the gist condition, all pair-wise comparisons were significant at a $p < 0.001$ such that more SPA details were generated than EP details than SD details. We also compared the proportion of details that were SPA between the two conditions and found a significant effect [$F(1, 23) = 49.50$, $p < 0.001$; $\eta_p^2 = 0.68$]. Under the gist condition, a greater proportion of details were SPA (mean 0.56, SE 0.021) compared to the detail condition [mean 0.39, SE 0.023; $t(23) = 7.04$, $p < 0.001$, $d = 1.55$] (Table 2).

Egocentric spatial reference estimates

When the familiar route descriptions were analyzed for the number of self-references (a metric of the reliance on an egocentric spatial representation), there were more self-references made in the detail (mean 23, SE 2.8) than gist condition [mean 12, SE 1.4; $t(23) = 4.44$, $p < 0.001$, $d = 0.89$]. However, when differences in output were taken into account by examining the ratio of self-references to the overall word count, a greater proportion of the descriptions included self-references for the gist (mean 0.09, SE 0.008) compared to the detail condition [mean 0.06, SE 0.0005; $t(23) = 3.63$, $p = 0.001$, $d = 0.80$].

Section summary

Routes described in the detail condition contained numerically more details and were associated with a greater sense of presence than those described in the gist condition. When the number of details was accounted for, routes described in the gist condition contained proportionally more SPA than those described under the detail condition, indicating a stronger reliance on schematic spatial details in the gist condition than the detail condition. The familiar routes described in the gist condition also contained proportionally more self-references, a measure of using an egocentric spatial frame of reference, than the route described in the detail condition.

Navigation problem solution descriptions

Subjective ratings

The repeated measures MANOVA test with condition as a within-subject factors and subjective ratings of sense of presence and vividness as dependent variables was not significant [$F(3, 21) = 0.14$, $p = 0.87$, $\eta_p^2 = 0.01$]. The difference for perceived length estimates was also not different across conditions [$t(23) = 0.14$, $p = 0.89$, $d = 0.03$].

Route description details

The 2 by 3 repeated measure ANOVA that examined the effects of condition (gist vs detail) and detail type (SPA vs EP vs SD) resulted in significant main effects of condition and detail type [$F(1, 23) = 7.12$, $p = 0.014$, $\eta_p^2 = 0.24$; detail type $F(1, 23) = 40.37$, $p < 0.001$, $\eta_p^2 = 0.64$] as well as a significant interaction between these two factors [$F(2, 46) = 7.31$, $p = 0.002$, $\eta_p^2 = 0.24$; left side of Fig. 4]. More details were generated in the detail (mean 14.3, SE 1.3) compared to the gist condition (mean 10.2, SE 2.1; $p = 0.014$). Overall, more EP (mean 18.1, E 2.6) than SPA details (mean 13.4, SE 1.2; $p = 0.03$) were generated and these averages were both greater the average for SD (mean 5.3, SE 1.4; $p < 0.001$). The interaction between condition and detail type was driven by more SPA details generated in the detail compared to the gist condition [$t(23) = 6.83$, $p < 0.001$, $d = 1.44$], but there was no condition difference in the number of EP details [$t(23) = 0.36$, $p = 0.72$, $d = 0.08$] or SD [$t(23) = 1.77$, $p = 0.09$]. Comparing the proportion of SPA details between the conditions led to a significant difference [$F(1, 23)$ 26.53, $p < 0.001$; $\eta_p^2 = 0.54$], such that the routes described under the gist condition had a higher proportion of SPA details (mean 0.57, SE 0.14) compared to the detail condition (mean 0.44, SE 0.09).

Given that the solution routes were adaptations of the familiar route, we assessed the change in the number and type of details used to describe new solution routes from the original route. To this end, we calculated 'detail deviation estimates' by subtracting the number of details from the original routes (i.e., description task) from the number of details in the solution route descriptions for each detail category and ran a 2 (condition) by 3 (detail) repeated measures ANOVA on these estimates. This resulted in main effects of condition and detail type [$F(1, 23) = 11.16$, $p = 0.003$, $\eta_p^2 = 0.32$; detail type $F(1, 23) = 24.85$, $p < 0.001$, $\eta_p^2 = 0.52$] as well as a significant interaction between these two factors [$F(2, 46) = 15.02$, $p < 0.001$, $\eta_p^2 = 0.40$]. To investigate the interaction effect, we examined whether each deviation estimate differed from zero for each detail category for each condition (n.b., one outlier was removed from this analysis). These deviations are illustrated in Fig. 5. For the detail condition, all deviation estimates were negative values such that more details were generated in the original than the solution route, but this effect was only significant for deviations in EP details [$t(22) = 4.66$, $p < 0.001$, $d = 0.97$; SPA $t(22) = 2.04$, $p = 0.06$, $d = 0.43$; SD $t(22) = 1.42$, $p = 0.17$, $d = 0.29$]. For the gist condition, the EP deviation was significantly positive in value [$t(22) = 4.02$, $p = 0.001$, $d = 0.84$] whereas the SPA deviation estimate was significantly negative in value [$t(22) = 3.31$, $p = 0.003$, $d = 0.69$] and the SD estimate was positive in value but not significant [$t(22) = 1.90$, $p = 0.07$, $d = 0.40$]. That is, for the gist condition, more EP and fewer SPA details were generated during the solution route as compared to the original familiar route (Table 3).

Route efficiency estimates

When we compared the estimates of distance deviation from the described route, this value was numerically larger for the solution routes described in the gist (mean 283 m, SE 85 m) than the detail condition (mean 136 m, SE 70 m), but this difference was not significant [$t(22)$ 1.26, $p = 0.22$, $d = 0.26$]. We then examined if these estimates could be predicted by the dependence on schematic spatial descriptions by running stepwise linear regressions models that examined how the proportion of details that were SPA for the initial route and solution route descriptions predicted route efficiency estimates for each condition. No linear regression equation was significant for the detail condition [$F(2, 22) = 0.324$, $p = 0.772$], but the linear regression equation that was significant for gist condition [$F(1, 21) = 7.21$, $p = 0.001$, $R^2 = 0.26$] included only the SPA proportions from the initial route description as a predictor value [$b = -1986$, $t(21) = -2.69$, $p = 0.014$]. The negative beta value indicates that the greater reliance on SPA details during the initial route description led to a lower distance deviation estimate.

Section summary

Overall, these data indicate that solution routes were described with more descriptors in the detail than the gist condition. However, generating new solution routes did not

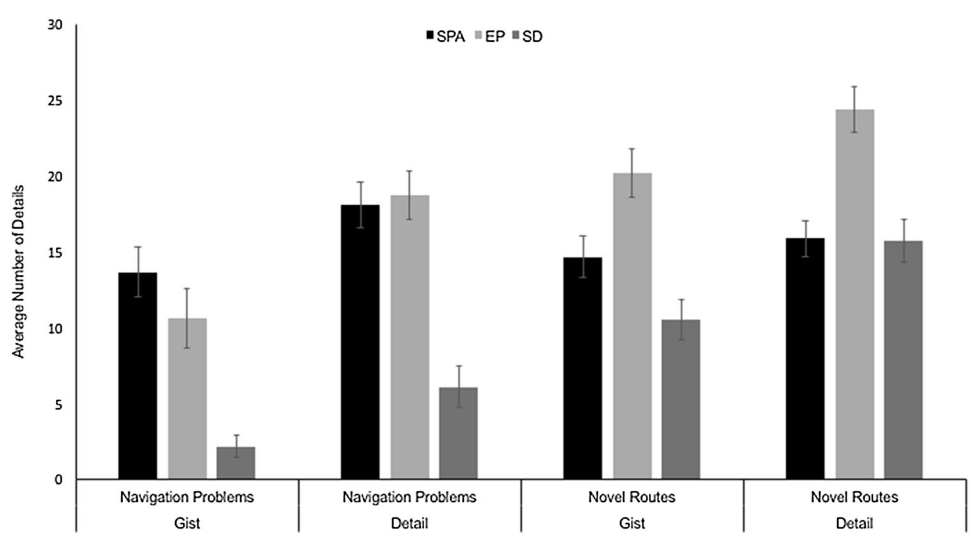


Fig. 4 The average number of spatial references (SPA), entities present (EP) and sensory descriptions (SD) contained in the descriptions of the solution routes to the navigation problems in the descriptions given during novel route task for the detailed and gist condition. *Standard error bars* are shown

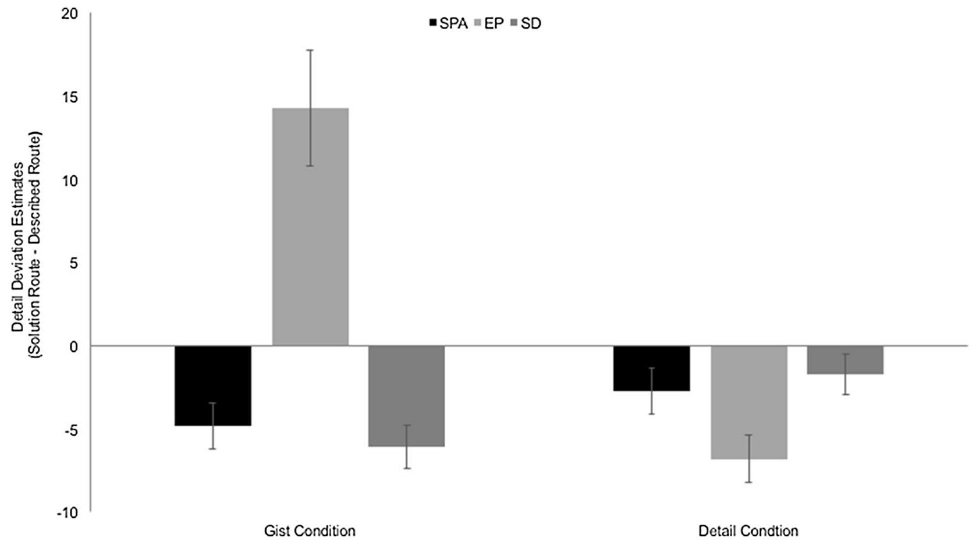


Fig. 5 The average difference (detail deviation) in the number of spatial references (SPA), entities present (EP) and sensory descriptions (SD) between the solution route and familiar route descriptions in the detail and gist condition. A *positive number* indicates more details were generated in the solution route description and a *negative number* indicates more details generated in the familiar route description. *Standard error bars* are shown

Table 3 The average subjective ratings (top) and the average number of details that were classified as a spatial reference, entity, or sensory description (bottom) for the navigation problem solution route description task for each condition (gist and detail)

	Condition	Mean	SE
Rating			
Sense of presence	Gist	3.19	0.20
	Detail	3.31	0.22
Vividness	Gist	3.35	0.17
	Detail	3.39	0.15
Length estimate (*M*)	Gist	1005	120
	Detail	1023	133
Detail			
Spatial reference (SPA)*	Gist	8.63	1.15
	Detail	18.10	1.52
Entities present (EP)	Gist	17.56	4.02
	Detail	18.73	1.60
Sensory description (SD)	Gist	4.46	1.55
	Detail	6.08	1.33

* A difference between conditions at $p < 0.05$

require recalling any additional details in the detail condition, and did require retrieving new entity information in the gist condition. We also found that while the solution routes described in the detailed condition were more efficient (numerically) than those from the gist condition, this was not a significant difference. Finally, we found that route efficiency could be predicted by the proportion of details that were spatial references in the original description of the familiar route for the gist but not the detail condition. Taken together, these data suggest there is less systematic change between the way a familiar route is recalled and manipulated when episodic processes are engaged (detail condition) than when they are not engaged, as is the case in the gist condition.

Novel route descriptions

Subjective ratings

The repeated measures MANOVA with condition as a within-subject factors and the subject ratings of sense of presence, vividness, and route familiarity as dependent variables was significant [$F(3, 21) = 3.23$, $p = 0.04$, $\eta_p^2 = 0.12$]. However, none of the follow-up univariate tests were significant (sense of presence; $F(1, 23) = 1.88$, $p = 0.18$; vividness, $F(1, 23) = 0.52$, $p = 0.48$; familiarity, $F(1, 23) = 3.10$, $p = 0.09$). Estimates of the perceived length were not different between conditions [$t(23) = 0.14$, $p = 0.89$; upper portion of Table 4].

Route description details

To examine the details used to describe the novel routes, we ran a 2 by 3 repeated measure ANOVA with condition (gist vs detail) and detail type (SPA vs EP vs SD) as within-subjects. There were main effects of condition and detail type [$F(1, 23) = 10.06$, $p = 0.004$, $\eta_p^2 = 0.30$; detail type $F(1, 23) = 34.41$, $p < 0.001$, $\eta_p^2 = 0.60$], which were the result of more details generated in the detail than gist condition (mean 18.6, SE 1.2 and mean 15.1, SE 1.2, respectively; $p = 0.004$) and more EP details (mean 22.3, SE 1.2) than either SPA or SD details (mean 15.3, SE 1.1; mean 13.1, SE 1.3; $p < 0.001$), which did not differ from one another ($p = 0.41$). Interestingly, the interaction effect between condition and detail type was also significant [$F(2, 46) = 3.71$, $p = 0.03$, $\eta_p^2 = 0.13$]. This effect was not due to condition differences in the number of SPA

[$t(23) = 1.05$, $p = 0.31$, $d = 0.20$], but rather due to significantly more EP [$t(23) = 2.23$, $p = 0.04$, Cohen's $d = 0.55$] and SD [$t(23) = 5.06$, $p < 0.001$, $d = 0.76$] details generated in the detail than the gist condition (bottom portion of Table 4; Fig. 4).

We investigated the link between familiar route descriptions and forming new route representations with a series of bivariate correlations between the number of details used in the familiar and the novel route description. For the detailed condition, there were significant correlations between the number of SPA details generated during familiar route description and all details (SPA, EP, SD) used for the novel route description. The relation between the number of EP and SD details during the familiar route description did not correlate with the number of SPA details used for the novel route. For the gist condition, generating SPA during the novel route description correlated only with the number of SPA and SD details generated during the familiar route description.

Section summary

To summarize this section, the detail condition in comparison to the gist condition promoted the recall of specific (i.e., entity and sensory descriptions) but not schematic (i.e., spatial references) details for newly learned routes. The correlational results further indicate that the ability to learn and recall specific details for a novel route is linked to the specificity with which a past route is recalled most strongly for the detail condition.

Table 4 The average subjective ratings (top) and the average number of details that were classified as a spatial reference, entity, or sensory description (bottom) for the novel route description task for each condition (gist and detail)

	Condition	Mean	SE
Rating			
Sense of presence	Gist	3.13	0.26
	Detail	2.83	0.25
Vividness	Gist	3.00	0.15
	Detail	3.13	0.15
Familiarity#	Gist	1.21	0.27
	Detail	0.79	0.24
Detail			
Spatial reference (SPA)	Gist	14.63	1.36
	Detail	15.88	1.19
Entities present (EP)*	Gist	20.21	1.59
	Detail	24.38	1.52
Sensory description (SD)*	Gist	10.54	1.32
	Detail	15.71	1.44

* A difference between conditions at $p < 0.05$

A difference between conditions at $p < 0.1$

Discussion

In this study, we examined how different approaches to remembering (i.e., retrieval orientations) affected the way real-world routes were recalled, the ability to flexibly use details from recalled routes and the effect of these approaches on forming new mental spatial representations. In a within-subjects design, we manipulated whether participants took a detailed or gist approach to retrieving well-known walking routes from their daily life by prompting the participants to recall rich detailed accounts or gist-like schematic representations, respectively. We contrasted the consequences of these two forms of remembering approaches on the subsequent ability to solve and describe solutions to navigation problems within the recalled familiar route (describe a new route when a street is blocked; describe navigating to a new but similar location) and to learn and recall a newly viewed walking route. The resulting descriptions were scored for the number and type of details present.

We report three main findings. Our first finding was that detailed remembering, a form that promoted the use of episodic memory processes (Madore & Schacter, 2014, 2016), led to familiar routes recalled with more overall detail and less reliance on spatial reference details than gist remembering. Our second finding was that detailed remembering, as compared to gist remembering, led to a more flexible use of familiar details when creating new routes with retrieved route information. Our third finding was that a detailed remembering approach led to preferentially encoding and recalling sensory–perceptual descriptive information from a new environment when compared to gist remembering. We first discuss the specific implications of each of these findings and then discuss the implications of these findings altogether (Table 5).

Remembering familiar routes

Manipulating the recruitment of episodic processes when mentally navigating a familiar route led to routes being recalled with more details. Specifically, a detailed (episodic) remembering approach led participants to recall proportionally more sensory and entity-related details than a remembering approach that relied on using general spatial representations to recall that route (gist remembering). During gist remembering—when episodic processes were not promoted at retrieval—familiar routes were recalled with more schematic spatial reference details. This result reinforces the idea that recovering specific sensory and perceptual elements of a traveled route is the domain of episodic memory processes (Hirshhorn et al., 2011; Maguire et al., 2016; Moscovitch et al., 2006; Rosenbaum

Table 5 Pearson correlations between detail types (SPA = spatial references; EP = entities present; SD = sensory description) for the familiar route description task and the novel route task for each condition (gist and detail)

	Novel route SPA	Novel route EP	Novel route SD
Gist condition			
Describe SPA	0.47*	0.13	0.06
Describe EP	0.32	0.19	0.01
Describe SD	0.46*	0.26	0.07
Detail condition			
Describe SPA	0.39*	0.52**	0.49*
Describe EP	−0.06	0.55**	0.66***
Describe SD	0.15	0.52**	0.66***

* $p < 0.05$

** $p < 0.01$

*** $p < 0.001$

et al., 2005). More generally, this result supports that remembering is flexible and that we recall information differently depending on certain factors of retrieval, including one's own internal state (retrieval orientation; for some reviews on this topic, see Rubin et al., 2014; Schacter & Addis, 2007; Schacter et al., 2012; Sheldon & Levine, 2016).

Our results also expand on prior work that has indicated that promoting episodic processes at retrieval (i.e., detailed remembering) alters the way several cognitive tasks are performed. Prior work has found episodic-specific enhancements for tasks such as recalling autobiographical events and imagination (Henkel, 2014; Madore et al., 2014; Madore & Schacter, 2014, 2016; Madore et al., 2016; Rudoy et al., 2009) and we extend these findings to the domain of recalling real-world spatial representations (also see Hirshhorn et al., 2011).

Navigating familiar routes in new ways

Another finding from our study was that recruiting episodic processes during familiar route recall affected the way new representations were created within these familiar route representations. We found that new routes generated within familiar environments required accessing more entities (landmarks) if that environment was initially recalled with a gist representation but not when it was initially recalled with a detailed representation. In other words, instating episodic processes during the initial recovery of a familiar route activated all the details necessary to act flexibly with that spatial representation (i.e., create a solution route to a navigation problem). Taking a gist approach to retrieval provided only the schematic elements to create a new (solution) route within the familiar environment, which is why new informational details had to be recovered to solve the navigation problems in the gist condition.

Another finding of note from our study was that our measure of route effectiveness, estimates of the deviation in the length of the solution route from the original route, was numerically twice as large in the gist as compared to detail condition, suggesting that routes recalled in the detail condition were more effective. However, this difference was not significant, which may simply reflect the insensitivity of our measures, evident by the large distribution of scores. Supporting the hypothesis that route efficiency is different between our tested conditions, spatial references generated during the initial route description predicted route efficiency estimates (i.e., distance deviations) for the gist but not detail condition. We interpret this finding as evidence that the solutions generated during the gist condition are based on map-like representations more than those formed during the detail condition, an idea that requires further testing.

More broadly, the reported condition differences on navigation problem task performance are consistent with the role of hippocampally mediated episodic memory processes in flexibly using information within a spatial context (Maguire et al., 2016) and fit with work that has indicated that hippocampal processes allow for old information to be adaptively applied to current mental activities (Rubin et al., 2014; Schacter & Addis, 2007) by forming new relations (Eichenbaum, 2004; Konkel & Cohen, 2009; Olsen, Moses, Riggs, & Ryan, 2012). These findings also align well with embodied cognition views that propose an adaptive function of multi-modal mental simulations (Barsalou, 2008, 2010). In our study, we find that the multisensory richness with which a (spatial) memory is recovered led to more adaptive—or at least different—uses of that spatial simulation/representation, which speaks to current understandings of the functions of spatial and mnemonic processes (Rubin, 2006).

Learning new spatial routes

Our third main finding was that detailed remembering selectively affected the ability to learn and remember sensory and entity details of routes in new spatial environments. That is, promoting the use of episodic processes for remembering affects the encoding of unrelated information. One intriguing way to interpret this finding is with the attention to memory hypothesis, which states that top–down attentional processes that are supported by extra-hippocampal processes (i.e., parietal lobes processes) will direct and orient attention towards memory representations during retrieval (Cabeza, 2008; Ciaramelli, Grady, & Moscovitch, 2008; Corbetta & Shulman, 2002). Thus, detailed remembering activated these attentional processes towards sensory and perceptual elements of the familiar route representations, which subsequently primed the participants to focus their attention to these details during the new route learning task (see above references).

Contrasting episodic support for forming familiar and novel spatial representations

Taken together, our findings indicate that there are dissociable effects of detailed remembering—promoting episodic retrieval processes—on using familiar and learning new spatial information, suggesting that different aspects of episodic memory contribute to how we form old and new spatial representations (for a related recent commentary, see Cohen, 2015). One possibility is this reflects the functional division of labor within the hippocampus (Poppenk, Evensmoen, Moscovitch, & Nadel, 2013; Strange, Witter, Lein, & Moser, 2014) in which different hippocampal regions (e.g., the anterior and posterior hippocampus) support different episodic and spatial memory tasks. For instance, reports have found that mentally constructing novel scenes activates the anterior hippocampus and navigating one's environment activates the posterior hippocampus (Sheldon & Levine, 2016; Zeidman & Maguire, 2016). Although we did not directly test hippocampal involvement in our task, we hypothesize that detailed remembering engages both these hippocampal regions, but the distinct processes supported by the anterior versus posterior hippocampus are differently applied to mental navigation that relies on using familiar information (the navigation problems) and mental navigation that relies on creating a representation of a completely new environment (the novel route task).

Finally, we consider that the differences we report between the detail and gist conditions reflect the use of different spatial frames of reference. In our study, we assessed spatial navigation with tasks that were inherently egocentric since we asked participants to imagine themselves navigating routes. Established theories of navigation processing (Jacobs & Schenk, 2003; Moscovitch et al., 2005) indicate that accessing spatial information from an egocentric perspective is achieved without hippocampal processes. However, to translate egocentric views of space into an allocentric representation requires updating processes supported by the hippocampus. Allocentric frames of reference—and the ability to move between egocentric and allocentric frames—provides access to contextual and sensory spatial details and allows for the flexible reorganization of spatial representations (Burgess, Becker, King, & O'Keefe, 2001; Byrne, Becker, & Burgess, 2007). In the detail condition, the promoted use of hippocampal episodic processes may have activated updating processes wherein allocentric spatial representations of familiar routes were accessed and used flexibly when creating novel iterations of the routes (problem task). Since the gist condition activated an initially less-flexible egocentric spatial representation, additional details (i.e., entities) were needed to perform the navigation problem task. Evidence for this hypothesis comes from the stronger reliance on self-references ("I turned left"; "On my left") during the familiar description in the gist versus detail condition. Since we did not directly manipulate the use of egocentric versus allocentric representations, this hypothesis remains speculative and a fruitful avenue for research.

Conclusion

Our study aimed to contrast the effects of distinct approaches to remembering on mental navigation. Specifically, we tested how a detailed compared to a gist remembering approach led to qualitatively different ways of recalling familiar real-world walking routes. We tested how these qualitative differences affected the flexible use of familiar route representations and navigating through new spatial environments. We demonstrated that activating episodic memory processes during retrieval (i.e., detailed remembering) promoted the flexible use of existing spatial representations and enhanced the encoding of sensory–perceptual details of new spatial environments. These findings provide new insights into the dynamic and reconstructive nature of memory processes as it pertains to spatial representations. We note a few issues and limitations of our experiment. First, all participants completed the subsequent navigation tasks in the same order (e.g., description task, the navigation problems, then the novel route task). Although the order of these tasks was the same across the tested conditions, this consistent order may have affected performance differently when taking a detailed or gist remembering approach. Another potential limitation is that we did not ask participants how often they traveled their submitted routes nor did we ask about the strategy used to navigate the route (e.g., taking an egocentric and allocentric approach), factors that could have affected performances. Addressing these limitations may be interesting avenues for future research. A natural next step is to examine the precise role of the hippocampus to these different forms of remembering spatial representations, given the strong link between the episodic memory and hippocampal function.

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Compliance with ethical standards

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Conflict of interest Both authors (SS and AR) declare no conflict of interest.

Ethical approval All procedures reported in this manuscript were in accordance with the ethical standards of McGill University.

Informed consent All individual participants in these studies gave their written informed consent.

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