Walking through doorways differentially affects recall and familiarity.

[1]Seel, S.V., [1,3]Easton, A., [1,3]McGregor, A., [1,3]Buckley, M.G., and [1,2]Eacott, M.J.*

[1] Department of Psychology, Durham University, Durham, DH1 3LE, UK

[2] Department of Psychology, University of Essex, Colchester, Essex, CO4 3SQ, UK

[3] Centre for Learning and Memory Processes, Durham University Durham, DH1 3LE, UK

*Corresponding author: Madeline J. Eacott

Address for correspondence:

Department of Psychology,
University of Essex,
Wivenhoe Park,
Colchester,
Essex, CO4 3SQ.
UK

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Abstract

Previous research has reported that walking through a doorway to a new location makes memory for objects and events experienced in the previous location less accurate. This effect, termed the location updating effect, has been used to suggest that location changes are used to mark boundaries between events in memory: memories for objects encountered within the current event are more available than those from beyond an event boundary. Within a computer-generated memory task, participants navigated through virtual rooms, walking through doorways, and interacting with objects. The accuracy and their subjective experience of their memory for the objects (remember/know and confidence) were assessed. The findings showed that shifts in location decreased accurate responses associated with the subjective experience of remembering but not those associated with the experience of knowing, even when considering only the most confident responses in each condition. These findings demonstrate that a shift in location selectively impacts recollection and so contributes to our understanding of boundaries in event memory.

Introduction.

Although we are subjected to a continuous stream of perception and behaviour (punctuated by periods of sleep), our memory experience is, in contrast, of a series of events or episodes (e.g. drinking a coffee, attending a meeting) around which our memories are structured (Conway & Pleydell-Pearce, 2000). Episodic memory is the memory for events in one's life and is associated with a conscious recollection of the event being remembered (Tulving 1983; Tulving 2002). Tulving (1983) defined human episodic memory as that which "receives and stores information about temporally dated episodes or events, and temporal-spatial relations between them".

It has been suggested (e.g. Eacott & Norman 2004; Easton and Eacott, 2008) that external context (such as, but not limited to, location) is one important aspect of our memories which serves to differentiate the stream of experience into separate episodes or events. Thus a spatial shift to a new location may serve as a boundary marker in segmenting a continuous information input into discrete events. For example, when reading a text, reading speed slows around an implied shift in spatial location (Zwaan, Radvansky, Hillyard & Curiel, 1998) and memory for objects mentioned before a shift declines (Radvansky & Copeland, 2006). A similar effect has been noted with memory for objects seen in films (Boltz, 1992; Schwan & Garsoffky, 2004) and while navigating in virtual reality (Radvansky & Copeland 2006; Radvansky, Tamplin & Krawietz, 2010; Radvansky, Krawietz & Tamplin, 2011; Horner, Bisby, Wang, Bogus & Burgess, 2016) and a real-life laboratory (Radvansky et al., 2011): in each case a shift of location marked an event boundary in memory evidenced by both less accurate and slower memory responses for objects encountered before the shift than after. This effect has been termed the location updating effect (Radvansky & Copeland, 2006). As simple explanations of such effects (e.g. context-dependency: Murnane, Phelps & Malmberg, 1999) have been excluded (Radvansky et al., 2011), this effect has been interpreted as revealing the effects of updating a cognitive event model (Radvansky et al., 2010; Radvansky et al., 2011).

A cognitive event model is a mental representation of the current event, a segment of time which the observer experiences as a connected whole, for example making a cup of tea or attending a meeting. Events can be organised hierarchically, such that the event of attending a meeting might itself be composed of sub-events such as informal pre-meeting catch-up with colleagues, formal discussion of X, post-meeting planning for Y, etc. (Richmond, Gold & Zacks, 2017). Event models represent the spatial-temporal context of the activity (Radvansky, 2017). According to two dominant and complementary accounts of the effect, Event Segmentation Theory (EST: Kurby & Zacks, 2007; Zacks et al., 2007) and the Event Horizon Model (EHM: Radvansky, 2012; Radvansky & Zacks, 2011, 2014), the current event model can be viewed as a schema held in working memory and used to process on-going perceptions. The currently active event model influences what information is maintained in working memory. Thus perceiving an event boundary will require a new event model to be activated and previously active information associated with the previous event model will become inactive, although it may still be potentially retrievable from long-term memory. This process of updating to a new event model serves to segment the continuous stream of information into events in memory.

The location updating memory effect is typically studied using a recognition memory paradigm (e.g. Radvansky et al., 2010; Radvansky et al., 2011). Participants view or interact with a series of objects while viewing or traversing a number of locations. Periodically, participants are presented with either a recently encountered object (positive probe) or novel object (negative probe) and asked "*is this a recently encountered object*?", thus testing recognition memory for the objects. However, recognition memory testing in this way does not delineate the memory processes involved in making the memory judgement. It has long been argued (e.g. Mandler, 1980; Yonelinas 1994; 2001) that such recognition judgements may reflect two distinct underlying processes: recollection and familiarity. Recollection is associated with a subjective experience of remembering the previous episode and involves bringing to mind information from the encoding event that was not present at test, while familiarity is a feeling that the event seems familiar in the absence of being able to generate any additional information from the encoding event. The distinction between the memory processes underlying recollection and familiarity is supported by a number of lines of evidence, including effects in both brain damaged (e.g. Aggleton & Brown 2006; Edylstyn, Grange, Ellis & Mayes, 2015) and intact human observers (e.g. Yonelinas, 1994, Ameen-Ali, Norman, Eacott, & Easton, 2017). To date, the contribution of recollection and familiarity to the location updating effect has not been investigated.

The current study aims to replicate the location updating effect based on that used by Radvansky and colleagues (e.g. Radvansky & Copeland 2006; Radvansky et al., 2010; Radvansky et al., 2011) and extend it to examine the underlying memory processes involved. Participants navigated around a computer-generated environment consisting of a number of rooms, interacting with virtual objects within each room. As in the studies of Radvansky and colleagues (Radvansky & Copeland 2006; Radvansky et al., 2010; Radvansky et al., 2011), periodic recognition tests probed memory for objects that had been recently encountered, either shortly before or shortly after traversing to a new room (a location shift). Unlike the previous studies, participants were additionally asked about their subjective memory experience in making this recognition memory judgement. When participants judged that they recognised an object as one they had recently encountered, they were asked whether this judgement was based on a subjective experience of "remembering" the previous experience or on a feeling of "knowing" that it was familiar but in the absence of remembering. This Remember/Know paradigm has been extensively used in the literature (e.g. see Yonelinas,

2001) to indicate the use of recollective and familiarity memory process respectively. In this way we examine the memory processes underlying the location updating effect.

Methods

Participants

Fifty participants were recruited through an online Psychology subject pool available to undergraduate Psychology students at a UK university and given partial course credit for their participation or the chance of winning £50. Four participants did not complete the study after reporting motion sickness during the procedure. Two further participants were excluded after initial examination of their data: these participants scored 50% and 58% correct respectively (c.f. average of all other participants = 89%, range 71%-98%) and in both cases the pattern of responses to positive and negative probes suggested they had not engaged with the task. The results of the remaining 44 participants are therefore reported. The experiment was approved by the University's Psychology Ethics Committee.

Materials and apparatus

The materials and apparatus were based on that of Radvanksy et al. (2011). The virtual environment was constructed, compiled and displayed using Mazesuite software (Ayaz, Allen, Platek, & Onaral, 2008; www.mazesuite.com) on a standard laptop. Participants were asked to navigate through a computer-generated virtual environment from a first-person perspective using the cursor keys to generate movement. The virtual space was a 55 room environment with rooms of two possible sizes: large rooms were twice as long as small rooms in order for Shift and No-Shift conditions to involve the same distance travelled. Small rooms contained one, and large rooms two, rectangular tables placed alongside a wall (see Figure 1). At one end of the table was the object to be picked up while the remainder of the table was available to set down the object carried from a previous table. The tables were arranged such that the distance between the last object and the door was the same in both the long and the small room. In addition, the distance between the last object of table 1 in the long room and the first object of the table 2 was the same. The distance between Shift and no Shift probes was identical.

Virtual objects were created by combining different colours (red, orange, yellow, green, blue, purple, white, brown, grey and black) and shapes (cube, wedge, pole, disc, cross and cone). All combinations of colour and shape were possible as objects.

Procedure

After giving informed consent, participants were instructed in the use of remember/know judgements (Easton et al. 2012; Rajaram, 1993) and were encouraged to practice navigating the virtual environment without objects present using the arrow keys on a standard keyboard before beginning the study.

Forty eight trials were presented in two blocks with a brief break between blocks. The study consisted of the participant navigating the environment, moving from table to table and between rooms. Close approach to a table allowed any carried object to be set down automatically and the object on the table to be picked up. When an object was being carried it disappeared from view so that participants had no visual cue as to the currently carried object. The 55-room environment contained 48 probe trials. Each probe trial consisted of three questions. First, a picture of an object appeared on the screen with the question "*Is this an object you are carrying or recently have put down?".* Half the probe objects were objects that had been amongst the last two objects carried (positive probes) and half were objects which had not been recently carried (negative probes) but were generated by recombining the object and colour from the two positive objects. For example, if the carried object was a red cone, and the set-down object a blue cube, the probe might be a blue cone. Half of the probes occurred after a shift to a new room (Shift condition) and half did not (NoShift condition). There were 24 positive probes and 24 negative probes, counterbalanced across conditions. Having responded to the probe object, participants were asked about their subjective experience, making a 'Remember', Know', or 'Guess' judgement and, if remembered or known, to rate their confidence in the accuracy of their memory on a 4 point scale labelled very unconfident, unconfident, confident, very confident.

Thus in total there were 48 probe trials, half of which occurred after a shift in location (Shift condition) and half not (NoShift condition). Within each condition half of the probes were positive and half negative. The condition (Shift/NoShift) and question type (positive/negative) of the probes was in random order. The experimental procedure was self-paced but participants were encouraged to be fast and accurate and were aware that reaction times were being measured. The procedure typically lasted between 20 and 25 minutes.

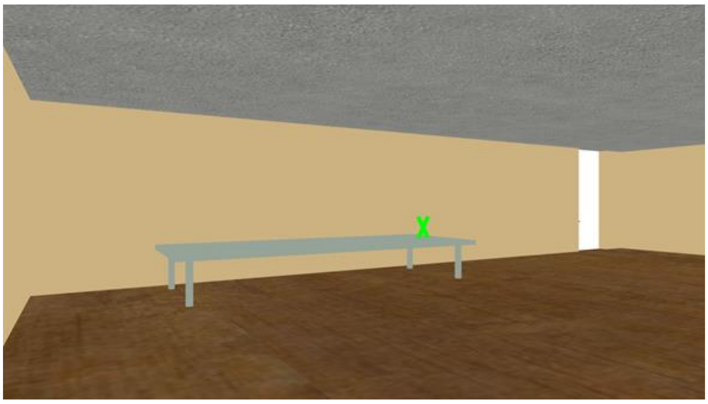

Figure 1. Screenshot of the virtual environment showing an object on a table with a doorway on the right-hand side.

Results

Following Radvansky et al., (2011), Table 1 shows the error rate and reaction time in each condition by question type. A 2x2 repeated measure ANOVA of error rates on condition (Shift, NoShift) and question type (positive, negative) showed an effect of condition (F=9.971, df= 1,43, p=0.03) such that the NoShift condition produced a lower error rate than the Shift condition. No effect of question type (*F*<1) nor interaction of condition and question type was found (*F*<1).

	NoShift			Shift		
	ErrorRate [95%CI]	RT (all) [95%CI]	RT (correct) [95%CI]	ErrorRate [95%CI]	RT (all) [95%CI]	RT (correct) [95%CI]
Positive	0.09 [0.05, 0.12]	3208 [2986, 3430]	3181 [2958, 3404]	0.14 [0.10, 0.17]	3482 [3262, 3701]	3421 [3201, 3641]
Negative	0.10 [0.06, 0.13]	3459 [3239, 3678]	3464 [3243, 3685]	0.12 [0.09, 0.16]	3607 [3385, 3829]	3608 [3378, 3839]

Table 1: Error rate and RT in Shift and NoShift condition by question type (positive vs negative)

Following Radvansky et al. (2010), the reaction time data were trimmed by removing any response faster than 200 ms or slower than 10,000 ms as being implausibly fast or slow. This removed an average of 0.64 reaction times per participant. A 2x2 repeated measure ANOVA of reaction time on condition (Shift, NoShift) and question type (positive, negative) showed an effect of condition (*F*=19.604, *df*= 1,43, *p*<0.01) such that the NoShift condition produced faster reaction times than the Shift condition. There was also an effect of question type as negative responses are, as commonly found in the literature (e.g. Sternberg, 1966, Marcell,1970), slower than positive responses (*F*=20.689, *df*=1,43, *p*<0.01) but there was no interaction of condition and question type (*F*=2.425, *df*=1,43, *p*=0.127).

Because differences in reaction times between-conditions might be affected by the above difference in error rates, the reaction times for correct responses only were analysed, again revealing an effect of condition (*F*=11.032, *df*= 1,43, *p*<0.01) such that the NoShift condition produced faster reaction times than the Shift condition. There was also the expected effect of question type (*F*=22.222, *df*=1,43, *p*<0.01) but no interaction of condition and question type (*F*=1.357, *df*=1,43, *p*=0.250).

Thus overall the results replicate the previous findings in the literature that walking through a doorway reduces accuracy and increases reaction times. As question type had no effect on response accuracy, it was not further analysed.

Table 2 shows the number of correct responses and the percentage of correct responses by condition and experiential response. A 2 condition (Shift, NoShift) x 3 experiential response (Remember, Know, Guess) ANOVA on the number of correct responses revealed as above a main effect of condition ($F=9.188$, $df=1,43$, $p=0.004$) as shifting location produced fewer correct responses overall. There was as expected also an effect of experiential response as Remember, Know and Guess responses were not equally common ($F=305.127$, $df=2,86$, $p<0.001$) but crucially there was an interaction of shift condition and experiential response ($F=8.004$, $df= 2,86$, $p=0.001$). Planned comparisons showed the number of correct responses associated with a Remember response significantly decreased when walking through a doorway ($t=3.271$, $df=43$, $p=0.002$) while in contrast following a location shift there was a marginally significant increase in the number of correct responses associated with a Know response ($t=1.949$, $df=43$, $p=0.058$). The number of Guess responses was low overall and the number of such correct responses did not differ between conditions ($t<1$).

		Condition			
		NoShift		Shift	
		Absolute number [95%CI]	Percent of responses in condition [95% CI]	Absolute number [95%CI]	Percent of responses in condition [95% CI]
Experiential response	Remember	18.32 [17.05, 19.59]	83.6% [78.7, 88.4]	16.50 [15.09,17.92]	78.0% [72.6, 83.4]
	Know	3.05 [2.07, 4.02]	14.2% [9.7, 18.6]	3.80 [2.90, 4.70]	19.0% 14.3, 23.6]
	Guess	0.48 [0.27,0.69]	2.3% [1.2, 3.5]	0.61 [0.31, 0.92]	3.1% [1.5, 4.8]
	Total	21.85	100%	20.91	100%

Table 2: The number and percentage of correct responses by condition and experiential response [95%CI]. Percentages may not sum to 100% due to rounding effects.

A similar analysis of the percentage of correct responses in each condition associated with each experiential response confirmed the conclusions of the above. There was, as expected, no effect of shift condition overall ($F<1$) as the data were the percent correct within condition and so summed to 100%. There was also, as expected, a highly significant effect of experiential response as each response was not equally common ($F=835.618$, $df=1,43$, $p<0.001$). Crucially, there was again a significant interaction of experiential response and condition ($F=6.131$, $df=1,43$, $p=0.017$). Planned comparison showed that the percentage of correct responses associated with a Remember response decreased after walking through a doorway ($t=2.642$, $df=43$, $p=0.011$) while conversely the percentage of correct responses associated with a Know response increased ($t=-2.504$, $df=43$, $p=0.016$). There was no effect on Guess responses ($t<1$).

It was possible that the differences between Remember and Know responses found above were influenced by a fall in memory confidence following a shift in location, as Remember responses are typically associated with high confidence while Know responses can vary across the confidence range (Yonelinas, 1994; 2001) . Consequently, an additional analysis was confined to high confidence responses only, defined as only those responses for which the participant rated their confidence as “confident” or “very confident” (see table 3). Guess responses are, by definition, not high confidence responses.

		Condition			
		NoShift		Shift	
		Absolute number [95%CI]	Percent of responses in condition [95% CI]	Absolute number [95%CI]	Percent of responses in condition [95% CI]
Experiential response	Remember	17.70 [16.45, 18.96]	87.6% [83.0%, 92.2%]	16.09 [14.66, 17,52]	82.6% [78.1%, 87.2%]
	Know	2.39 [1.50, 3.28]	12.6% [8.2%, 17%]	3.05 [2.31, 3.78]	17.5% 13.1%, 21.9%]
	total	20.09	100%	19.14	100%

Table 3: The number and percentage of high confidence correct responses by condition and experiential response [95%CI]. Percentages may not sum to 100% due to rounding effects.

A 2 (Shift, NoShift) x 2 (Remember, Know) repeated measures ANOVA on the number of high confidence correct responses again revealed a main effect of condition (*F*=5.042, *df*=1,43, *p*=0.03) as shifting location produced fewer high confidence correct responses overall. There was also the expected effect of experiential response as Remember and Know responses were not equally common (*F*=230.058, *df*=1,43, *p*<0.001), but crucially there was, as above, an interaction of shift condition and experiential response (*F*=8.18, *df*= 1,43, *p*=0.007). Planned comparisons showed that the number of high confidence correct responses associated with a Remember response significantly decreased following a location shift (*t*=3.083, *df*=43, *p*=0.004). In contrast there was no difference between the two conditions in the number of such correct responses associated with a Know response (*t*=1.814, *df*=43, *p*=0.077), although as before there was a numerical increase in correct Know responses after a location shift which approached significance.

As above, a similar analysis based on percentage rather than absolute values was undertaken. This revealed, as before, no effect of shift condition (*F*=2.048, *df*=1,43, *p*=0.16) and a significant effect of experiential response (*F*=296.458, *df*=1,43, p<0.001). Crucially, there was again an interaction of shift condition and experiential response (*F*=6.213, *df*=1.43, *p*=0.017), as correct high confidence Remember responses significantly decreased following a shift in location whereas correct high confidence Know responses conversely increased.

In order to fully assess memory availability, reaction times by condition and experiential response were also analysed (Table 4). Because Guess responses were relatively uncommon across all participants, many participants had no correct Guess responses in one or more conditions and so for this reason, the reaction times for Guess responses were not included. Nonetheless 13 participants also had no correct responses in one or more category of shift condition x experiential response even when only Remember and Know responses were considered and so all reaction time data of these participants were also removed before analysis. A 2 (Shift, NoShift) x 2 (Remember, Know) ANOVA on reaction times for the remaining participants revealed a main effect of shift condition (F=16.678, df=1,30, p<0.001) such that correct responses in the shift condition were slower than those in the non-shift condition. There was also a significant effect of experiential response (F=7.990, df=1,30, p=0.008) as remember responses were faster than know responses but there was no interaction (F<1, df=1,30, p=0.332).

		Condition			
		NoShift		Shift	
		Reaction time [95%CI]	High confidence reaction time [95% CI]	Reaction time [95%CI]	High confidence reaction time [95% CI]
Experiential response	Remember	3179 [2951, 3406]	3222 [2980, 3464]	3462 [3220, 3704]	3481 [3233, 3753]
	Know	3442 3057, 3826]	3368 [2982, 3753]	3914 [3561, 4266]	3948 [3573, 4324]
	total	3310 [3036, 3585]	3295 [3018, 3572]	3678 [3354, 4001]	3715 [3453, 3977]

Table 4: Reaction time of correct responses by condition and experiential response.

Due to the above discussed issue of confounds of confidence and experiential response, as above an analysis was also undertaken on the reaction times of high confidence correct responses only (Table 4). An additional 3 participants had no high confidence responses in one or more category of shift condition x experiential response and so their data were removed before analysis. A 2 (Shift, NoShift) x 2 (Remember, Know) ANOVA on high confidence reaction times on the data from the remanding participants revealed a main effect of shift condition (F=15.534, df=1,27, p=0.001) such that high confidence responses in the shift condition were slower than those in the non-shift condition. There was also, as above, a significant effect of experiential response (F=5.457, df=1,27, p=0.027) but no interaction (F=2.346, df=1,27, p=0.137).

Discussion

The purpose of the current study was to investigate the memory processes underlying the location updating effect. Having first replicated the previously reported location updating effect (Radvansky & Copeland 2006; Radvansky, Tamplin & Krawietz, 2010; Radvansky, Krawietz & Tamplin, 2011), our results reveal for the first time that this effect is seen only in memories experienced as remembered but not those experienced as known or those which the participant rated as guesses.

The current study therefore adds to the literature on the updating effect and crucially allows it to be placed within the broader framework of memory processing. The interpretation of remember/know judgements has proved controversial but have been used as a basis to understand and model memory processes. One dichotomy in the literature is whether remember/know judgements reflect different memory strengths within a single process memory system (e.g. Donaldson, 1996; Dunn, 2004) or are evidence of at least two dissociable memory processes (such as recollection and familiarity: Yonelinas 2001; Wixted & Mickes, 2010). For example, it has been suggested that differences in memory strength within a single process results in differences in both subjective experience and confidence:

high memory strength produces a confident experience of remembering and low memory strength results in a low confidence experience of knowing (Dunn 2004). Under this view, a lowering of memory strength as a result of a location shift could potentially be advanced as an explanation of some of our current findings: decreasing confidence would shift the subjective experience from high confidence remembering towards low confidence knowing. However, there is strong evidence from within our data that this is not the correct explanation of our findings. Even when only highly confident responses were analysed, accurate Remember responses still significantly decreased following a location shift, while accurate Know responses increased. This pattern of results is not consistent with an effect caused merely by a lowering of memory strength following a location shift. It is, however, consistent with a view that the experiences of remembering and knowing result from two dissociable processes: a location shift differentially affects those processes which are experienced as remembered but not those associated with the experience of knowing. The findings from the current study therefore support the view that remember and know judgements map onto the two processes of recollection and familiarity, although it is not claimed that this mapping is necessarily one-to-one (Wixted and Mickes, 2010).

One aspect of our data may at first seem paradoxical: shifting location appears to increase the familiarity of objects experienced in the previous location. However, it should be noted that an experience of Knowing is produced when one has the subjective experience of familiarity in the absence of remembering (Yonelinas 2001; Wixted & Mickes, 2010): as walking through a doorway has been seen to decrease the experience of remembering, in some cases this will reveal Know responses which were previously hidden by Remember responses. Thus walking through doorways does not increase familiarity of objects *per se* but, by decreasing Remember responses, may allow Know responses to more frequently reach experience. Similar increases in responses associated with familiarity have been seen following decreases in recollective processes after hippocampal damage in both amnesic patients (Holdstock, Mayes, Gong, Roberts & Kapur, 2005) and rats (Easton, Zinkivsky, & Eacott 2009).

The current study followed the existing literature by using a doorway as a marker of a change in location leading to event segmentation. While there is evidence that navigating virtual environments using arrow keys while sitting stationary at a computer as in our study produces cognitive activity similar to real navigation (Kahana, Sekuler, Caplan, Kirschen & Madsen), it is not crucial to the argument that the participants experienced a virtual location shift. The current findings are consistent with the view that more generally context changes including, but not limited to, spatial context serve to delineate episodes in episodic memory (e.g. Gaffan 1994; Eacott and Norman 2004; Eacott and Easton, 2010; Eacott & Norman 2004; Easton & Eacott 2008). Under this view, the concept of a context is broad and incorporates changes in spatial location, background context and temporal context as well as, for example, changes in task demands (Easton & Eacott, 2008). In the current study, Shift and NoShift conditions were intermixed and the probe questions were a constant time following object interaction regardless of condition, so there were no temporal cues that could serve as a marker of a change in context. Moreover the background context was physically the same between rooms so the only marker of a change in context was the act of navigating through a doorway to the next virtual room. It has been argued that by incorporating the context (spatial or otherwise) in which an event occurred into a memory representation, similar memories can be protected from interference (what-where-which occasion: Robertson, Eacott & Easton, 2015). In consequence, individuals who segment events effectively have been shown to have better memory for the events than those whose segmentation was less effective (Richmond et al., 2017; Zacks et al, 2006).

It might perhaps seem surprising that episodic memory processes such as recollection and familiarity have been implicated in such a task as the delay between object interaction and the memory probe, although dependent on the participant's speed of navigation, was typically under 10 seconds. At such delays working memory might be assumed to be implicated rather than long-term episodic memory processes. However, various models of episodic memory assume a short-term buffer which may be implicated (e.g. Baddeley, 2012; Lehman & Malmberg, 2013). The episodic buffer of Baddeley's working memory model (Baddeley, 2000; Baddeley, 2012), for example has been proposed as a multidimensional short-term store capable of holding integrated representations of features of objects (such a colour and shape) as well as integrating between working and long-term memory (e.g. Baddeley et al., 2011; Karlson et al., 2010). The use in the current study (and those of Radvansky and colleagues: Radvansky & Copeland 2006; Radvansky, Tamplin & Krawietz, 2010; Radvansky, Krawietz & Tamplin, 2011) of negative probe objects which recombined the colours and shape of recently encountered objects (positive probe objects) required an integrated representation of colour and shape for accurate responding and thus may have specifically required the episodic buffer. It is possible that a similar task that did not require such feature integration might be less reliant on the episodic buffer and thus less susceptible to the location updating effect, although this is at present untested. The episodic buffer is the least well explored aspect of Baddeley's working memory model and its role is not yet fully elucidated, including its relationship to the subjective experience of remembering and so this model does not specifically make any predictions regarding the experience of remembering or knowing. In contrast, Lehman and Malmberg (2013) proposed a buffer model in which information is stored about items, and about associations between items and the context in which they were encountered. Given that the buffer has a limited capacity, in response to task demands items and associations may be removed from the buffer by a control process termed compartmentalization. It is suggested that during a task such as the one in the current study, an episodic image of each object will be stored in the buffer and may be associated with the context (room) in which the object was seen. A context shift resulting from walking through a doorway may potentially result in removal of context associations within the buffer, leaving item only information. It has been suggested (Mickes, Seale-Carlisle & Wixted, 2013) that Know judgments may often be based on such item-only information. These buffer accounts of our data are highly speculative but illustrate how the location updating effect may prove useful in further exploring how the stream of input available in working memory is segmented into events within episodic memory.

In summary, the previously reported finding (Radvansky & Copeland 2006; Radvansky et al., 2010; Radvansky et al., 2011) that walking through a doorway reduces the availability of information in memory can be confirmed and extended. Memories associated with the experience of remembering are reduced but the number of those associated with the experience of knowing is not reduced, and may even be increased. This pattern of results is consistent with an interpretation of the effect occurring within the episodic memory system and can shed light both on the location updating effect and the processes of episodic memory.

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