The Flexibility of Episodic Long-Term Memory-Guided Attention and the Impact of Reinstating Context

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Abstract

While it may seem that salient visual events, like the flashing lights on an ambulance, can automatically capture our attention, capture is actually under our control. Depending on our current internal goals, we adopt attentional control settings (ACSs) that specify what stimuli in the environment capture our attention. It has been shown that ACSs can be defined based on long-term episodic memory representations. For example, when searching for the items on your grocery list, an ACS can be specified based on your long-term memory of the list, such that your attention will be drawn to those items, and only those items. Importantly, episodic memories incorporate contextual information that can enhance recall when reinstated (e.g., you will remember your grocery list better if it was memorized at the grocery store rather than at home). Here we asked whether reinstating context can enhance the establishment of long-term memory ACSs. Participants memorized two sets of 15 images of objects in a particular context (i.e., a coloured box in a particular spatial location), that they then searched for, inducing an episodic-based ACS for those objects. During the search task, this encoding context was either reinstated, or not. We found that individuals are able to flexibly switch between ACSs and sources of information. However, we did not find sufficient evidence for the effect of context on the establishment of ACSs or their flexibility. This study extends our understanding of the factors that influence memory-guided attention, and the impact of contextual reinstatement on the formation of ACSs.

Keywords: attentional control settings, visual attention, long-term episodic memory, contextual reinstatement

Introduction

Episodic memory plays an important role in mediating our attention. After repeated experiences with an event, memory can guide our attention to help us find specific stimuli from that event (Hutchinson & Turk-Browne, 2012). For example, it is easier to find your car keys at home than at a hotel, because you have knowledge of where you have kept your keys in the past. This example displays how we can use our long-term memory (LTM) of the past to voluntarily guide attention in the present. Interestingly, it has been demonstrated that LTM not only guides how we choose to deploy attention—it can also influence which stimuli in the environment reflexively capture our attention. For example, your friend might stand out in a crowd in comparison to someone you have never met before. Additionally, our attentional capture relies on our internal goals, known as attentional control settings (ACSs) (Parrott, Levinthal, & Franconeri, 2010). These settings can vary depending on the task's demands (Folk, Remington, & Johnston, 1992). Previous research has found that individuals can adopt ACSs based on long-term episodic memory representations

(Giammarco, Paoletti, Guild, & Al-Aidroos, 2016). These representations contain contextual information of past personal events, commonly referred to as episode-defining context. Contextual information has been shown to play an important role in episodic retrieval, as re-experiencing the original encoding context at retrieval is beneficial for memory performance (Bramão, Karlsson, & Johansson, 2017; Hayes, Nadel, & Ryan, 2007; Isarida & Isarida, 2014). However, it is unclear whether contextual reinstatement will improve *flexibility* of ACSs—that is, whether contextual reinstatement will improve and individual's ability to switch from one ACS to another. Therefore, the current study will investigate whether individuals can flexibly adopt attentional goals, and whether the reinstatement of context aids that flexibility.

Rapid Serial Visual Presentation (RSVP) Task

The spatial and temporal allocation of visual attention is commonly studied using the rapid serial visual presentation (RSVP) task. During such tasks, visual stimuli are presented

rapidly one after the other in the same location, and participants are required to identify a target that is differentiated from the other stimuli (non-targets) in some way (Shapiro, Raymond, & Arnell, 1994). For example, participants might be asked to identify the one green letter that appeared in a stream of red letters. Thus, this task requires individuals to form an ACS for the target-defining properties i.e., an ACS for the colour green. Studies have shown that if a distractor that matches the ACSs (e.g., a green stimulus presented adjacent to the stream), appears within 500 ms before the target, it will cause a *spatial or attentional blink* in which perception of the target is disrupted by involuntarily orienting attention to the distractor (Folk, Leber, & Egeth, 2002). This involuntary shift of attention causes individuals to “miss” the target and decreases their accuracy on the task. Therefore, the RSVP task can be used to assess what ACSs participants have adopted by determining which types of stimuli capture their attention (i.e., produce a spatial blink), and which do not. The current study will use this task to assess whether individuals can adopt ACSs for previously studied information and the flexibility of this ability

The Role of Episodic Memory in ACSs

Episodic memory can guide visual attention. Given that the retrieval of information from LTM is conventionally thought to be a slow and a difficult process, it may seem surprising that LTM retrieval could occur quickly enough to alter what stimuli in the environment capture our attention (Giammarco et al., 2016). Recently, a two-staged model of LTM retrieval has been proposed: the initial stage of retrieval is rapid, unconscious, and involuntary, followed by a slow, conscious, and deliberate stage (Moscovitch, 2008). The rapid episodic retrieval stage can guide rapid attentional capture (Giammarco et al., 2016) and performance on tasks such as speeded visual search (Guild, Cripps, Anderson, & Al-Aidroos, 2014). Therefore, visual information resembling what we have previously learned commonly captures our attention in our environment. After multiple experiences of an event, episodic memory can be manipulated to find specific stimuli from that event. The presentation of a context that previously contained a target image facilitates target detection in a target search task similar to a spatial cue (Murnane, Phelps, & Malmberg, 1999). In addition, the successful retrieval of episodic memories has been suggested to capture attention by increasing the saliency of previously encountered stimuli (Hutchinson & Turk-Browne, 2012). Several studies have shown that learning and memory aid performance in visual search tasks, such that individuals navigate faster when presented with a familiar context compared to when they are presented with a novel context (Chun & Jiang, 1998, 2003; Summerfield, Lepsien, Gitelman, Mesulam, & Nobre, 2006). Additionally, it has been shown that individuals use memory to constrain what types of stimuli can capture their attention in a stimulus-driven way. Giammarco and colleagues (2016) have recently extended this past work by showing that long-term episodic memory can specifically mediate attentional

capture, as ACSs can be adopted and defined based on long-term memory representations. Participants in their study memorized two sets of visual object images (e.g., a polar bear, a clock, a belt, etc.) and completed a spatial blink RSVP task where they needed to find any object from one of the sets (target set) while ignoring the items from the second set (non-target set). Shortly before the target object appeared, distractor objects would appear above and below the central RSVP stream (stream of images appearing rapidly, one after the other in the centre of the computer screen). One of these distractor objects was either from the target set or the non-target set. Giammarco and colleagues (2016) found that accuracy scores were lower when participants were shown a target distractor, suggesting that ACS-matching stimuli uniquely captured attention. Thus, individuals were able to form ACS for previously studied information tied to a specific context or source (i.e. set).

The finding that episodic memory can support the establishment of ACSs has interesting implications for the flexibility of these settings, as episodic memory is a particularly flexible and high-capacity memory system. Episodic memory allows for rapid associative encoding and flexible memory representations. This flexibility allows individuals to retrieve elements of an episode individually or in relation to each other (Henke, 2010). Moreover, it has been suggested that the flexibility of episodic retrieval can be impacted by our internal goals. A neuroimaging study by Herron, Evans, & Wilding (2016) investigated this idea by recording event-related potentials while participants frequently switched between retrieval tasks. They found differences across all the tasks when switches were required, highlighting the adaptability of memory retrieval. Given the flexibility of episodic memory encoding and retrieval, does the same flexibility extend to ACSs that are defined based on episodic memory representations?

The Role of Context in Episodic Memory

Episode-defining context consists of the information that was at the focus of attention and the information that was peripheral to the focus of attention during processing (Murnane et al., 1999). For example, if the event was your friend’s birthday party, the information at the focus of your attention could be your friend and other people that were at the party, while the information at the periphery of your attention could be the physical environment, like the room of the house you were in. Contextual information plays an important role in the success and flexibility of episodic memory retrieval. The contextual information of episodes can include factors like the physical environment, emotional or physiological state, and even stray thoughts that occurred during encoding (Murnane et al., 1999). The encoding specificity principle states that the best cue for retrieving an item in memory is the information that was stored with that item (Tulving & Thomson, 1973). Thus, episodic retrieval can be promoted when the encoding context is reinstated. The overlap between encoding and retrieval increases the

likelihood that information will be successfully remembered (Tulving & Thomson, 1973). Several studies have shown that reinstating encoding context at retrieval benefits memory performance (Bramão et al., 2017; Isarida & Isarida, 2014; Summerfield et al., 2006). This effect was shown by Polyn (2005) in which cortical activity of participants was measured during a free recall task of either faces, locations or objects, using functional magnetic imaging. It was found that just before participants recalled an item from one of the cued categories, their pattern of cortical activity resembled the pattern that was present during the encoding of the images from that category. Thus, reinstating the encoding context of the memory representations during retrieval may also impact ACSs that are guided by those memory representations. In order to process important environmental events, individuals need to flexibly adapt to changing behavioural goals and circumstances (Folk et al., 1992). Flexibility in ACSs has been theorized to be important, and there are some demonstrations that this flexibility exists (Folk & Remington, 1996). The current study investigated whether reinstating the encoding context during the RSVP task will aid the establishment of ACSs and the flexible allocation of attention onto stimuli matching the ACSs.

The present study investigated whether people can flexibility change their attentional goals (i.e. swap back and forth between different groupings of information), the role of context in establishing episodic memory-guided ACSs, and whether contextual reinstatement enhances the flexibility of such ACSs. Participants started the experiment by memorizing two sets of visual objects in distinct encoding contexts. These contexts were enhanced by presenting each set on opposite sides of the screen (left or right) and surrounding each set with a differently coloured box (red or blue). Participants then completed a spatial blink RSVP task for one of the sets of objects, while ignoring the other. The encoding context of the target set was reinstated during the spatial blink task for some participants, but not for others (i.e., the stimuli appeared in the centre of the display with no surrounding box). Additionally, flexibility was tested by having participants switch target sets half way through the spatial blink task, such that the previously ignored objects were now targets. The impact of context was investigated by comparing the accuracy scores of participants who received context to those that did not, before and after the switch. Understanding these aspects of attention can lead to a more complete understanding of the underlying processes of attentional control, as well as the mechanisms that impact how ACSs are implemented.

Method

Participants

For this experiment, data was collected from 129 undergraduate students from the University of Guelph, who received partial course credit as compensation for their participation in this study. Participants were allotted 90 minutes to complete the experiment. Participants who did not

complete the experiment were not included in the analyses. All participants reported having normal or corrected-to-normal visual acuity, and normal colour vision.

Apparatus and Stimuli

The experiment was conducted on a desktop computer with a Windows operating system with a 1280 x 1024 resolution CRT display with a refresh rate of 75 Hz. Participants used a standard keyboard for responses. Two sets of images comprising many categories such as tools, vehicles, animals, clothing, food, and appliances (Brady, Konkle, & Alvarez, 2009) were used in the memory training task and the spatial blink task. A chin and head rest were used to keep participants eyes at a consistent distance (30 cm) from the screen.

Procedure

Memory Training Task

Participants viewed two sets of fifteen images that were randomly selected from a pool of 125 images. One set of images appeared on the right side of the display in a red box (Set A) and the other set of images on the left in a blue box (Set B; see **Figure 1**). Participants were told which set they would be viewing prior to image presentation. Each image was presented one at a time for 3,000 ms on a white background, with an inter-stimulus interval of 1,000 ms. Participants were instructed to memorize the images from each set (i.e. 'Set A' or 'Set B'). Sets were presented one after the other, after which participants' memory was assessed using a recognition test. Specifically, all of the thirty images were re-presented in random order, along with novel images. Participants were asked to report whether each object belonged to 'Set A' or 'Set B'. Each image was presented until participants made their response or 2,000 ms elapsed, with an inter-stimulus interval of 520 ms. Participants repeated the memory training for at least four blocks, until achieving 90% accuracy on the last block of the recognition test. Incorrect responses were paired with a 500 Hz, 50 ms tone, to inform them when they made an error.

RSVP Task

Following the completion of the memory training task, participants completed a spatial blink task (**Figure 2**). They were instructed to monitor the centre of the screen for the appearance of an image from one set (target set) while ignoring the images from the other set (non-target set). Each trial began with a fixation frame: a black central fixation cross measuring $1 \times 1^\circ$ presented for 120 ms. Fixation was followed by a series of 20 image frames that each appeared for 120 ms with an inter-stimulus interval of 40 ms. The target image was located between the 11th and 16th frames. Two frames (i.e., lag 2) before the target image, a distractor frame appeared in which the central stimulus was flanked by two additional distractor images subtending $7 \times 7^\circ$, one 5° below the central

image, and the other 5° above. One of the distractor images was always a non-studied or novel image randomly selected from a database containing 2,152 images, while the other was either from the target or non-target set. The central image was either novel or from the non-target set. Participants were told that the distractors were irrelevant to their task and should be ignored. Participants were asked to fixate their vision on the central images during the image stream, and to report the identity of the target once the stream completed. During the no-context condition, images were presented in the centre of the screen. During the context condition the context of each set was reinstated and images were presented either on the left with a red box (e.g., Set A) or on the right in a blue box (e.g., Set B).

Following the stream of images, a selection frame with eight images (measuring $1 \times 1^\circ$) surrounding the black fixation cross appeared. One of the images was the target from the RSVP stream, and one was the non-target image from the RSVP stream; the remaining six images consisted of different images from the target set (three images) and the non-target set (three images) that had not appeared elsewhere during the trial. Participants were required to select the target image from the set using the number pad on the keyboard. The surrounding images all subtended $1 \times 1^\circ$ and were presented at eight separate locations on an imaginary $10 \times 10^\circ$ square centred on fixation. The target and non-target distractors were never present on the selection frame, to prevent participants from strategically attending to the distractors. The selection frame remained on the screen until participants responded. Incorrect responses were paired with a 500 Hz tone was generated for 50 ms.

The spatial-blink task consisted of 2 blocks, in which the targets are switched from block 1 to block 2. Each block contained 240 trials each (480 trials total), with all trials presented in a random order. All levels of distractor type (target studied set, non-target studied set, or non-studied) were fully crossed within subjects, and each unique combination of conditions occurred with equal frequency. The location of each image within the probe screen was randomly determined on each trial.

Memory Testing Task

Once participants completed the spatial-blink task, their memory of the images from both sets was tested. Similar to the memory training task, the studied and non-studied images were displayed one at a time in a random order (see **Figure 1; Right panel**). Participants were instructed to identify which set each image belonged to (i.e., Set A or Set B), using the keys on their keyboard. Incorrect responses were paired with a 500 Hz, 50 ms error tone.

Results

Participants were excluded based on three criteria: if they made combined non-target lure (i.e., picked non-target item that appeared in the stream) and non-target errors (i.e., picked non-target item that did not appear in the stream) for more than

25% of trials in block 1, if they made more non-target lure than target-lure errors, and if their accuracy on the RSVP task was lower than 30 % (i.e. if they were guessing and not completing the task properly). In total, 14 participants were excluded from the remaining analyses.

Memory Training Task

On average, participants completed 4.13 and 4.08 (*ns*) blocks of memory training in the no context and context conditions. Out of the 129 participants, eight (no context = 4, context = 4) required more than four blocks of memory training, the maximum being seven blocks. The average accuracy across participants and blocks in the no context condition was 94.93% and in the context condition was 94.29% (*ns*), suggesting that participants successfully memorized the required images and the source of the images (i.e., sets) in both conditions.

RSVP Task

The participants' accuracy on the RSVP task across both conditions and blocks is shown in **Figure 3**. It is evident that target distractors preferentially captured attention, leading to lower accuracy on target distractor trials than non-target distractor trials. However, these differences in scores due to distractors does not seem to differ across contexts. To assess the impact of context on performance, accuracy scores were subjected to a 2 (Distractor Type: target vs. non-target distractor) $\times$ 2 (Block: 1 vs. 2) $\times$ 2 (Context Type: context vs. no context) mixed ANOVA. The analysis revealed a main effect of distractor type, $F(1,127) = 0.12$, $p < .001$, $\eta^2 = .322$, $BF_{10} = 3.63 \times 10^6$ (see *Supplementary Information*), but not context type, $F(1,127) = 1.081$, $p = .301$, $\eta^2 = .008$, $BF_{10} = 0.48$. In addition, the analysis revealed a significant two-way interaction between block and distractor type, $F(1,127) = 14.29$, $p < .001$, $\eta^2 = .101$, $BF_{10} = 8.41$, but no three-way interaction between block, distractor type, and context type, $F(1,127) = 0.11$, $p = .889$, $\eta^2 = .000$, $BF_{10} = 0.20$.

As a more direct test of the impact of context on the establishment of ACSs, two separate 2 (Distractor Type: target vs. non-target) $\times$ 2 (Context Type: context vs. no context) mixed ANOVAs were conducted, one for each block. The analyses revealed no main effect of context in block 1, $F(1,127) = 1.67$, $p = .199$, $\eta^2 = .013$, $BF_{10} = 0.64$, and block 2, $F(1,127) = 0.50$, $p = .483$, $\eta^2 = .004$, $BF_{10} = 0.49$. Additionally, the two-way interaction between distractor and context in block 1 was non-significant, $F(1,127) = 0.06$, $p = .814$, $\eta^2 = .000$, $BF_{10} = 0.20$, and block 2, $F(1,127) = 0.004$, $p = .950$, $\eta^2 = .000$, $BF_{10} = 0.19$. To assess whether individuals were able to establish ACSs in both blocks, within-subject *t*-tests were conducted; comparing individuals accuracy scores for each distractor type within each block, in each condition. This revealed significantly worse performance on trials with target distractors than non-target distractors in block 1, $t(64) = -5.42$, $p < .001$, and block 2, $t(64) = -2.30$, $p = .025$, within the context condition. Additionally, participants performed significantly worse on trials with target distractors than non-

target distractors, in block 1, $t(63) = -5.49, p < .001$, and block 2, $t(63) = -2.25, p = .028$, in the no context condition. Consistent with these findings, on error trials in the context condition, participants chose an incorrect target set image (19% of total trials) more often than non-target set images (4% of all total trials). In the no context condition incorrect target set images (18% of total trials) were chosen more often than non-target set images (4% of total trials). These error rates suggest that participants could accurately recall the set/source of each set of images during the task, and any decrease in accuracy was due to a failure to detect the target image (i.e. due to a spatial blink).

Memory Testing Task

The average accuracy across participants in the no context condition was 97.60% and in the context condition was 97.47%, suggesting that participants successfully memorized the required images, and the source of the images, in both conditions. High accuracy in this task may also suggest that accuracy changes during the RSVP task were not due to the forgetting of the target images and their corresponding sets.

Discussion

The present study investigated whether reinstating the original encoding context enhances the establishment of ACSs, whether individuals can flexibly switch between ACSs, and whether contextual reinstatement enhances the flexibility of ACSs. Although it has been shown that individuals can establish ACSs based on long-term episodic memory representations (Giammarco et al., 2016a), and that contextual reinstatement can enhance episodic memory performance (Bramão et al., 2017; Murnane et al., 1999), the flexibility of ACSs and the role of context on attentional goals is unknown. Here, we found that context did not improve establishing ACSs, as there was no difference in block 1 performance across the context and no context conditions. Additionally, context did not enhance the flexibility of attentional goals, as there was also no difference in block 2 across the context and no context conditions.

This study has shown that individuals can successfully constrain memory-guided attention to information based on the sources of information (i.e. sets). This idea of source-constrained retrieval was initially investigated by Jacoby, Shimizu, Daniels, and Rhodes (2005), who examined whether participants could use source information (using shallow verses deep encoding instructions) to constrain what came to mind during retrieval using a memory-for-foils paradigm. Participants initially studied two sets of words, one in which they had to make pleasantness judgements (deep encoding), and the other where they had to state if the word had a vowel (shallow encoding). Participants then did two separate recognition tests, one in which they were shown the deeply studied words and new words (foils) and the other where they were shown the shallowly studied words and foils. Afterwards, their memory for the foils was tested. It was found

that the memory for foils was greater for foils that were intermixed with the deeply encoded words than for foils that were intermixed with shallowly encoded words, indicating that individuals were able to constrain memory retrieval based on the original encoding processes (i.e., source). Similarly, participants in the current study were able to establish attentional goals based on the source of encoding (i.e., Set A or Set B).

This idea that encoding processes can impact retrieval is also shown in studies that investigate the reinstatement of encoding context on memory performance. It is believed that remembering occurs when retrieval cues interact with memory traces. The greater overlap between the encoding processes and cues during retrieval, the greater the likelihood of successful retrieval (Tulving & Thomson, 1973). The importance of contextual overlap of encoding and retrieval has been highlighted in many studies, showing its benefits on memory performance (Bramão et al., 2017; Chun & Jiang, 1998; Isarida & Isarida, 2014; Murnane et al., 1999). However, in the current study these benefits are not evident, and in fact it may almost show the opposite effect; though not statistically significant, participants who had contextual reinstated had overall lower accuracy during the RSVP task than those who did not have context reinstated. This finding goes against a vast majority of research that explores the reinstatement of encoding context during retrieval.

Early evidence showing that attentional goals may be flexible was observed by studies that examined the effects of switching between two different tasks that involved different attentional sets. A study by Luks, Simpson, Feiwell, and Miller (2002) investigated the involvement of the anterior cingulate cortex (ACC) and dorsolateral prefrontal cortex (DLPFC), which have been previously implicated in attentional control and monitoring, during task switching in a cue-target paradigm that involved the reallocation of attention. They found that the DLPFC was active following all the cue conditions, while the ACC was only active following informative switch and informative repeat cue conditions. This finding suggests that the ACC is involved with monitoring the preparatory allocation of attention for conflict, while the DLPFC was involved in allocating attention to meet goals. Thus, this study provided preliminary evidence for the flexibility of attentional goals, by showing that the neural substrates of attentional control are active during the change of attentional goals. Other studies commonly reported conflict or competition between attentional sets, when tasks followed one another closely in time (Ferlazzo, Lucido, Nocera, Fagioli, & Sdoia, 2007; Wylie & Allport, 2000). However, this conflict would decrease with the increase of time in-between the tasks (Meiran, 1996). Additionally, episodic memory has the capacity for flexible retrieval. Giovanello, Schnyer, and Verfaellie (2009), using fMRI, found that the hippocampus, a structure required for the memory of facts and events, is active during flexible retrieval.

Consistent with these findings, the current findings suggest that individuals are able to flexibility switch between ACSs, and in turn, the sources of information on which the

ACSs are defined. Participants successfully established ACSs in both blocks, regardless of the condition. Although the ACSs in the second block were not as effective as those in the first block, this data suggests that participants were able to overcome their initial ACSs and implement a new attentional goal. Furthermore, one of the main goals of this study was to investigate whether reinstating context would enhance the flexibility of ACSs. The current findings do not show any evidence in support of an effect of context.

It may be the case that extrinsic context-dependency is more robust in recall rather than recognition tasks (D. Godden & Baddeley, 1980). Another possibility is that the context manipulation used in the current study was not salient enough to establish two distinct contexts. The contexts used during the RSVP tasks were a red or blue box placed on either the left or right side of the screen. These differences in context may have been too minor for the participants to properly distinguish between the two during retrieval. Future studies can test their manipulation by assessing if participants successfully associated the sets of images with the contexts. Additionally, future studies can make the context manipulation stronger, which may involve making the contexts more noticeable or informative to the sets that they are associated with. For example, each set could have an image of an environment in the background (e.g., forest). Conversely, this manipulation can involve changing the environmental context of each condition by having participants complete the tasks in different rooms, as the manipulation of extrinsic context has been shown to be an effective cue for recall in memory performance tasks. A study by Godden & Baddeley (1975) examined memory performance on a word recall task by having divers learn two lists of words: one on land and the other underwater. After this, they tested their memory for the two lists of words in both environments. They found that recall for the words was better when the divers were recalling the lists in the same environment that they learned them in.

The present findings demonstrate that individuals can flexibly switch between ACSs and the sources of information. While we did not find any evidence supporting the effect of context on the establishment of ACSs and their flexibility, this does not mean that contextual reinstatement does not play a role in memory-guided attention. There is a large body of literature that indicates that reinstating encoding context during retrieval improves performance on recall tasks. Future studies can build upon the current study to better assess this interaction. Such studies can aid in our understanding of the mechanisms that impact how attentional control settings are implemented and the underlying processes of attentional control.

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References

- Brady, T. F., Konkle, T., & Alvarez, G. A. (2009). Compression in Visual Working Memory: Using Statistical Regularities to Form More Efficient Memory Representations. *Journal of Experimental Psychology: General*, 138(4), 487–502. <https://doi.org/10.1037/a0016797>
- Bramão, I., Karlsson, A., & Johansson, M. (2017). Mental reinstatement of encoding context improves episodic remembering. *Cortex*, 94, 15–26. <https://doi.org/10.1016/j.cortex.2017.06.007>
- Chun, M. M., & Jiang, Y. (1998). Contextual Cueing: Implicit Learning and Memory of Visual Context Guides Spatial Attention. *Cognitive Psychology*, (36), 28–71. <https://doi.org/10.1006/cogp.1998.0681>
- Chun, M. M., & Jiang, Y. (2003). Implicit, Long-Term Spatial Contextual Memory. *Journal of Experimental Psychology: Learning Memory and Cognition*, 29(2), 224–234. <https://doi.org/10.1037/0278-7393.29.2.224>
- Ferlazzo, F., Lucido, S., Nocera, F. Di, Fagioli, S., & Sdoia, S. (2007). Switching Between Goals Mediates the Attentional Blink Effect. *Experimental Psychology*, 54, 89–98. <https://doi.org/10.1027/1618-3169.54.2.89>
- Folk, C. L., Leber, A. B., & Egeth, H. E. (2002). Made you blink! Contingent attentional capture produces a spatial blink. *Perception and Psychophysics*, 64(5), 741–753. <https://doi.org/10.3758/BF03194741>
- Folk, C. L., Remington, R. W., & Johnston, J. C. (1992). Involuntary covert orienting is contingent on attention control settings. *Journal of Experimental Psychology*, 118(4), 1030–1044. <https://doi.org/10.1037/0096-1523.118.4.1030>
- Folk, C. L., & Remington, R. W. (1996). When knowledge does not help: Limitations on the flexibility of attentional control. *Converging Operations in the Study of Visual Selective Attention*, 271–295. Retrieved from <http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:When+knowledge+does+not+help:+Limitations+on+the+flexibility+of+attentional+control.#0>
- Giammarco, M., Paoletti, A., Guild, E. B., & Al-Aidroos, N. (2016). Attentional capture by items that match episodic long-term memory representations. *Visual Cognition*, 24(1), 78–101. <https://doi.org/10.1080/13506285.2016.1195470>
- Giovanello, K. S., Schnyer, D., & Verfaellie, M. (2009). Distinct hippocampal regions make unique contributions to relational memory. *Hippocampus*, 19(2), 111–117. <https://doi.org/10.1002/hipo.20491>
- Godden, D., & Baddeley, A. (1980). When does context influence recognition memory? *British Journal of*

Psychology, 17, 99–104.

- Godden, D. R., & Baddeley, A. D. (1975). Context-dependent memory in two natural environments: on land and underwater. *British Journal of Psychology*, 66(3), 325–331.
- Guild, E. B., Cripps, J. M., Anderson, N. D., & Al-Aidroos, N. (2014). Recollection can support hybrid visual memory search. *Psychonomic Bulletin and Review*, 21(1), 142–148. <https://doi.org/10.3758/s13423-013-0483-3>
- Hayes, S. M., Nadel, L., & Ryan, L. (2007). The Effect of Scene Context on Episodic Object Recognition: Parahippocampal Cortex Mediates Memory Encoding and Retrieval Success. *Hippocampus*, 17(9), 873–889. <https://doi.org/10.1002/hipo.20319>
- Henke, K. (2010). A model for memory systems based on processing modes rather than consciousness. *Nature Reviews Neuroscience*, 11, 523. <https://doi.org/10.1038/nrn2850>
- Herron, J. E., Evans, L. H., & Wilding, E. L. (2016). Electrophysiological evidence for flexible goal-directed cue processing during episodic retrieval. *NeuroImage*, 132, 24–31. <https://doi.org/10.1016/j.neuroimage.2016.02.025>
- Hutchinson, J. B., & Turk-Browne, N. B. (2012). Memory-guided attention: control from multiple memory systems. *Trends in Cognitive Sciences*, 16(12), 576–579. <https://doi.org/10.1016/j.tics.2012.10.003>
- Isarida, T., & Isarida, T. K. (2014). Environmental context-dependent memory. *Advances in Experimental Psychology*, 8(2), 1–31. <https://doi.org/10.3758/BF03196157>
- Jacoby, L. L., Shimizu, Y., Daniels, K. A., & Rhodes, M. G. (2005). Modes of cognitive control in recognition and source memory: Depth of retrieval. *Psychonomic Bulletin and Review*, 12(5), 852–857. <https://doi.org/10.3758/BF03196776>
- Lavine, M., & Schervish, M. J. (1999). Bayes Factors: What They are and What They are Not. *The American Statistician*, 53(2), 119–122. <https://doi.org/10.1080/00031305.1999.10474443>
- Lee, M. D., & Wagenmakers, E.-J. (2013). *Bayesian Cognitive Modeling: A Practical Course*. Cambridge: Cambridge University Press. <https://doi.org/10.1017/CBO9781139087759>
- Luks, T. L., Simpson, G. V., Feiwell, R. J., & Miller, W. L. (2002). Evidence for Anterior Cingulate Cortex Involvement in Monitoring Preparatory Attentional Set. *NeuroImage*, 17(2), 792–802. <https://doi.org/10.1006/nimg.2002.1210>
- Ly, A., Verhagen, J., & Wagenmakers, E. (2016). Harold Jeffreys's default Bayes factor hypothesis tests: Explanation, extension, and application in psychology. *Journal of Mathematical Psychology*, 72, 19–32. <https://doi.org/10.1016/j.jmp.2015.06.004>
- Meiran, N. (1996). Reconfiguration of Processing Mode Prior to Task Performance. *Experimental Psychology: Learning, Memory, and Cognition*, 22(6), 1423–1442. <https://doi.org/10.1037/0278-7393.22.6.1423>
- Moscovitch, M. (2008). The hippocampus as a “stupid,” domain-specific module: Implications for theories of recent and remote memory, and of imagination. *Canadian Journal of Experimental Psychology*, 62(1), 62–79. <https://doi.org/10.1037/1196-1961.62.1.62>
- Murnane, K., Phelps, M. P., & Malmberg, K. (1999). Context-dependent recognition memory: The ICE theory. *Journal of Experimental Psychology: General*, 128(4), 403–415. <https://doi.org/10.1037/0096-3445.128.4.403>
- Parrott, S. E., Levinthal, B. R., & Franconeri, S. L. (2010). Rapid communication complex attentional control settings. *Quarterly Journal of Experimental Psychology*, 63(12), 2297–2304. <https://doi.org/10.1080/17470218.2010.520085>
- Polyn, S. M. (2005). Category-Specific Cortical Activity Precedes Retrieval During Memory Search. *Science*, 310(5756), 1963–1966. <https://doi.org/10.1126/science.1117645>
- Shapiro, K. L., Raymond, J. E., & Arnell, K. M. (1994). Attention to visual pattern information produces the attentional blink in rapid serial visual presentation. *Journal of Experimental Psychology: Human Perception and Performance*, 20(2), 357–371. <https://doi.org/10.1037/0096-1523.20.2.357>
- Summerfield, J. J., Lepsien, J., Gitelman, D. R., Mesulam, M. M., & Nobre, A. C. (2006). Orienting attention based on long-term memory experience. *Neuron*, 49(6), 905–916. <https://doi.org/10.1016/j.neuron.2006.01.021>
- Tulving, E., & Thomson, D. M. (1973). Encoding Specificity and Retrieval Processes in Episodic Memory. *Psychological Review*, 80(5), 352–373.
- Wylie, G., & Allport, A. (2000). Task switching and the measurement of “switch costs.” *Psychological Research*, 63(3–4), 212–233. <https://doi.org/10.1007/s004269900003>

Tables and Figures

Figure 1. Example of the trial sequence of the memory training task. *Left panel.* Memorization phase: Participants were shown two sets of 15 objects, with an inter-stimulus interval of 1000 ms, and were instructed to memorize each set of objects. *Right panel.* Recognition phase: Participants were shown 44 trials containing one object that was either from Set A, from Set B, or a new object, and were required to indicate if the object was from Set A, from Set B, or new. Both phases were repeated for four blocks. Participants needed to achieve 90% accuracy on the last two blocks, or both phases would repeat until they reached 90 % accuracy.

Figure 2. Trial sequence of the rapid serial visual presentation (RSVP) task. Participants were instructed to report the identity of a target image that was either from Set A or Set B (counterbalanced across participants) presented in the RSVP stream on each trial. Two distractors appeared flanking above and below the central image. One of the flanking distractors was always a non-studied object, while the other could be an image from the target set or the non-target set. *Left panel.* The context condition, in which context of the corresponding set (for this example, a blue box on the left) was reinstated during the RSVP. *Right panel.* No context condition, in which context was not reinstated and images were shown in the centre of the frame.

Figure 3. *** $p < .001$, * $p < .05$. Mean accuracy scores (error bars: SEM) of participants during the RSVP task, when participants were shown the target or non-target distractor across blocks. *Left panel.* Scores for participants in the no context condition. *Right panel.* Scores for participants in the context condition. Error bars in this figure are corrected (Morey, 2008) within-subject standard errors (Cousineau, 2005).

Supplementary Information

The Bayes Factor (BF) is reported for each analysis of variance in the results section. It can be interpreted as a measure of strength of evidence in favour of one hypothesis, among two (i.e., the null hypothesis; H_0 , or the alternate hypothesis: H_1) (Ly, Verhagen, & Wagenmakers, 2016). The current study displays the BF for the alternate hypothesis (i.e., BF_{10}). A BF_{10} of 1 suggests no evidence towards the alternate hypotheses, 1-3 suggests anecdotal evidence, 3-10 suggests moderate evidence, and > 10 suggests strong evidence (Lavine & Schervish, 1999; Lee & Wagenmakers, 2013).