Modulation of the Attentional Blink by Episodic Memory Traces

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Abstract

The present study investigated the role of episodic memory in shaping ongoing attention and perception. Leveraging an imagination paradigm to construct vivid episodic-like memories and a Rapid Serial Visual Presentation (RSVP) task to test how these memories interact with the selection of target information, two key hypotheses were tested. We proposed that memory-triggered reactivation of associated stimuli in the RSVP stream would lessen the attentional blink effect (Hypothesis 1), and that learnt targets would be perceived more accurately than new ones (Hypothesis 2). Our results provided support for both hypotheses, illustrating a strong interplay between episodic memory and perception. The attentional blink effect was mitigated for associated targets, suggesting an advantage in the processing of retrieved information. Moreover, a consistent preference for learnt over new stimuli was observed, a pattern that signals a potential interplay between top-down and bottom-up prioritization mechanisms. Overall, this research underscores the pivotal influence of episodic memory on the processing of new information, enhancing our understanding of how past experiences influence our current perceptions.

Modulation of the Attentional Blink by Episodic Memory Traces

As we remember past events, we are able to effortlessly bring to mind richly textured recollections of episodes, filled with multisensory perceptions, emotions, and contexts. This capacity for detailed recall, including the where and when of past events, is a defining feature of what is denoted as episodic memory (Tulving, 1972). More than a tool for reminiscence, episodic memory likely evolved to allow us to predict and prepare for future situations based on similar past experiences (Schacter & Addis, 2007; Suddendorf & Corballis, 2007). This anticipatory function critically enables effective navigation through the world, facilitating adaptive behaviour in response to forthcoming challenges (Hartley et al., 2021; Szpunar, 2010). As stimuli that have co-occurred in the past may be likely to re-occur together in the future, focusing cognitive resources on these associated stimuli, rather than on irrelevant or incongruent information, would enhance the efficiency of perception and response preparation. Episodic memory can thus help streamline information-processing and resource allocation by directing attention towards stimuli that were associated in the past. Attention, in turn, enhances the encoding of discrepancies between memory-based predictions and actual outcomes (Smout et al., 2019), thus refining future anticipations and increasing our preparedness for ensuing events. For memory to effectively guide attention, it should successfully undertake two critical tasks: firstly, it should form an accurate and cohesive representation of an event by encoding and consolidating its various elements; secondly, it would need the capability to rapidly access and retrieve these elements when a familiar situation arises, guiding ongoing perception and behaviour. Building upon these considerations, the primary objective of the thesis is to explore the influence of episodic memory on attentional processes and perception, focusing particularly on its role in forming comprehensive event representations and promptly retrieving these to inform and guide future behaviour.

Formation of Episodic Memories

The formation of episodic memory begins with the encoding process, which interweaves different elements of an event – such as people, objects, or scenes – into a cohesive mental representation of that event (Tulving, 2002). As the diverse facets of an experience are encoded, they leave what is known as a memory trace or engram – a neural imprint in the brain of that memory (Horn et al., 2001; Josselyn & Tonegawa, 2020).

Following the formation of new memory traces, episodic memory retrieval is a dynamic process that reactivates such traces to reconstruct past experiences (Schacter, 2012). Crucially, the reactivation of a memory trace for a stimulus from a specific event can potentially prompt the reactivation of additional traces for stimuli related to that same event, suggesting that recollection of past events may occur in all-or-none or holistic fashion (Joensen et al., 2020; Tulving, 1983). Horner et al. (2015) found that elements associated with the same discrete event show statistical dependency at retrieval, in that successfully retrieving one element was contingent upon reactivating the others. The finding exemplifies the phenomenon of pattern completion, in which one element from an episode can act as a "partial cue" that leads to the retrieval of all constituting elements of that episode (Horner et al., 2015; Marr, 1971; Nakazawa et al., 2002). Partial cues, including the context at encoding (Godden & Baddeley, 1975; Wälti et al., 2019), may thus aid memory retrieval and promote full recollection of the event.

Pattern completion is followed by a process termed ecphory or information reinstatement, which involves the cortical reactivation of memory traces that closely resembles neural sensory activity during encoding (Griffiths et al., 2019; Waldhauser et al., 2016). Pattern completion and memory reinstatement processes are theorised to be mediated by the medial temporal lobe (Eichenbaum et al., 2007; Liang & Preston, 2017; Schultz et al., 2022). In particular, the hippocampus is thought to act as a "memory hub" that guides the reactivation of associated memory traces stored in distinct areas of the neocortex (Alvarex & Squire, 1994; Nadel & Moscovitch, 1997; Staresina et al., 2016). Evidence suggests that this reactivation process is hierarchical and sequential, prioritising the retrieval of high-level conceptual information before the more sensory-based elements of an event (Linde-Domingo et al., 2019). At a phenological level, pattern completion and ecphory may underlie the subjective experience of holistic recollection of autobiographical memories, allowing one to "relive" different perceptions from a past experience (Wheeler et al., 2000).

Slow Versus Fast Episodic Recollection

Retrieving detailed information about past events has traditionally been viewed as a slow and effortful process, as argued by Yonelinas (2002) and substantiated by Staresina & Wimber's (2019) review. This view originates from research that has identified the earliest indications of recollection within the hippocampus at 500 ms. Initial hippocampal neural activity subsequently unfolds into a pattern completion process and the reactivation of memory traces, all occurring within a time span of 500–1500 ms. Staresina & Wimber (2019) argue that no earlier neural activity distinguishes successful from unsuccessful recollection trials, aside from responses to perceiving the cues or anticipation processes. However, recent empirical evidence challenges this classical view, positing that the neural reinstatement of memory traces may occur more rapidly and incidentally. Waldhauser et al. (2016) discovered neural signatures of ecphory as early as 100-200 ms after a retrieval cue's presentation, in the form of oscillatory brain activity changes in early visual areas contralateral to the spatial position of the encoded item. This activity was linked to the automatic cortical reinstatement of the item's spatial context during learning and was found to predict successful recollection judgements. Furthermore, the modulation of these oscillations via transcranial magnetic stimulation (TMS) interfered with later memory recall, underscoring ecphory's critical role in episodic retrieval. The existence of automatic and rapid neural reinstatement of episodic memory traces in the cortex, as early as 100-200 ms, challenges the view of a slower recollection process as presented in Staresina and Wimber's (2019) review.

A potential framework for reconciling these seemingly contrasting views could lie in the two-stage retrieval proposal of Moscovitch (2008). It posits that episodic recollection is not a unitary process but involves both fast and slow stages. Ecphory may represent an initial, more immediate and automatic stage of retrieval, where memory traces are first activated, followed by a secondary, more deliberate stage where memories are consciously accessed. This account would accommodate both the rapid, automatic processes evidenced by Waldhauser et al. (2016), and the slower retrieval processes leading to conscious recollection, as proposed by Staresina (2019).

Nevertheless, the debate remains unresolved. As Bowen & Kark (2016) noted, Waldhauser et al.'s (2016) novel findings of early ecphory processes, preceding recollection, may not apply universally to all episodic memory, as their study tested only memory for visual-spatial associations and TMS did not disrupt all memory recall. This underlines the need for further research to fully understand the precise mechanisms and timing of memory reactivation and retrieval.

Episodic Retrieval and Attention

The rapid and automatic retrieval of episodic memories would have critical implications for the ongoing processing of new information. As memory allows us to anticipate and prepare for what may come next, based on previous learning and experiences, its speed and automaticity would be particularly suited for navigating the fast-paced and ever-changing nature of our environment. With its unlimited capacity, the episodic memory system would further afford an advantage for biasing attention, offering potentially boundless and nuanced guidance by highly specific items encountered in the past (Plater et al., 2020). An exploration of this theoretical possibility comes from Ciamarelli & Moscovitch (2008), who found that, upon viewing a cue, the automatic retrieval of a memory linked to a spatial context consequently directed spatial attention towards the corresponding location. Giammarco et al. (2016) provided further evidence that episodic memory associations can play a crucial role in determining the focus of attention. Participants were asked to find a target among rapidly displayed images, based on a previously learned list membership. Crucially, their attention was unintentionally pulled towards irrelevant distractors in the stream, but only when these distractors shared the same list membership as the target. Therefore, a distractor could capture attention due to its episodic memory association with the target, being that they were both part of the same studied list. This strongly suggests that representations in episodic memory can guide our attention, making us more likely to notice items that are associated with what we are looking for. While Giammarco et al. (2016) concluded that their results indicate fast episodic retrieval, triggered by the perception of distractors shown as briefly as one-tenth of a second, the precise timing of this process in their experiment remains unclear. It is conceivable that the process of calling to mind specific list memberships could have started when participants received instructions to identify targets associated with a specific list prior to the onset of the task. Therefore, it is unclear whether the activation of memory traces rapidly occurred during the task itself, or whether these were retrieved at a slower pace at an earlier stage of the experiment.

While the aforementioned research has begun to shed light on how cues can prompt episodic recall, thereby influencing ongoing attentional processes, these studies have conceptualised episodic memory as simple pairwise associations between an item and its context at encoding – namely, its spatial location (Ciamarelli & Moscovitch, 2007) or list membership (Giammarco et al., 2016). However, everyday life experiences arguably form far more complex memories, encompassing several interacting elements including objects, people, and locations. A question that subsequently arises is how the fast and automatic retrieval of such complex, multi-element episodic memories would impact attentional processes related to the dynamic sampling of information from the environment. As information is selected through attention and undergoes further processing, some stimuli might act as partial cues that trigger a process of pattern completion (Horner et al., 2015), which in turns reactivate associated memory traces in one’s mind (Waldhauser et al., 2016). These reactivated traces could potentially bias the sampling of new information that may or may not match the reactivated memory traces, facilitating or hindering perception. This type of attentional biasing by episodic memory retrieval could be key to our ability to predict and respond to future events based on past experience, enabling us to monitor and learn from the fulfilment or violation of these predictions (Smout et al., 2019). It therefore remains to be explored how retrieval of intricate past episodes can impact ongoing attention and perception.

In the context of understanding how attention contributes to perception, the phenomenon of the attentional blink (AB) offers valuable insights. This phenomenon arises in a scenario where two visual targets are presented in quick succession within a rapid serial visual presentation (RSVP) of images or symbols. Often, individuals fail to report the second target if it appears less than 450 ms after the first one (Shapiro, 1994), reflecting a momentary “gap” in perception. Since its discovery, the attentional blink has been used to study conscious perception, the timing of encoding stimuli, and the deployment of attention (Martens and Wyble, 2011). The intriguing aspect of the attentional blink lies in its temporary disruption of perception, which has prompted exploration into the underlying mechanisms that may cause such perceptual "blindness". Research by Nieuwenstein (2005) proposes that the AB is likely due to a delayed attentional engagement following the processing of the first target, which in turn results in an inability to consolidate the second target into memory. This delay might reflect a fleeting attentional inhibition period, following the demanding process of selecting the first target for consolidation. Supporting the proposal, pre-cueing the second target with a similar stimulus can overcome the attentional delay, likely by initiating its selection sooner and allowing sufficient consolidation time without interference (Nieuwenstein et al., 2005). Following this line of reasoning, it could be deduced that any mechanism attracting attention to the second target in advance, such as the preactivation of its representation via an episodically-associated first target, could potentially attenuate the AB. This possibility suggests an interplay between selective attention and episodic memory that warrants further exploration.

The Present Study

The present study aims to investigate the interaction between fast episodic retrieval and attention using the RSVP paradigm. The quick succession of stimuli in a RSVP, typically at a 100 ms rate, effectively constrains the time available for participants to deliberately modulate their responses (Bowman et al., 2013; Chen et al., 2022). This feature makes it an effective candidate paradigm to examine the effects of fast and automatic memory retrieval on the processing of new information. Our primary query revolves around how the activation of a single element of an episodic memory might facilitate perception of an associated element in the stream.

In order to construct episodic-like memories to test how memory retrieval can influence attention, we utilized Horner and Burgess' (2013) imagination paradigm. Participants were asked to vividly imagine three-item scenarios in which they interacted with a person, an object, and a place. Following James et al.'s (2020) suggestion, realistic images were used as imagination prompts to promote the creation of vivid, specific mental images and improve consequent memory recall (Gjorgeva et al., 2022). All images used in the experiment were generated using Stable Diffusion, a generative AI tool that allows the creation of thousands of images that follow strict parameter settings. AI-generated images offer additional control and flexibility in selection over traditional stimuli databases (Becker & Laycock, 2023), while closely mimicking real photographs (Moshel et al., 2022). Memory strength for the imagined events was evaluated using a cued-recognition procedure (Joensen et al., 2020), where participants select the correct elements from the constructed mental scenarios given another element as a cue.

After the imagination task, a RSVP task was employed in which the two target pictures were drawn from either the encoded image set or a new pool of images. The first target (T1) was an image of a learnt face or object, while the second target (T2) could be either a learnt scene associated to T1, a learnt non-associated scene, or a novel scene. Assuming fast and automatic pattern completion and ecphory processes in response to cues, the detection of the first target should lead to the reactivation of related memory traces in the span of 100–200 milliseconds (Waldhauser et al., 2016). This reactivation should, in turn, affect processing of the upcoming target-scene in the stream, such that the attentional blink effect will be reduced when the second target is associated to the first target, as compared with learnt non-associated second targets (Hypothesis 1). Holistic retrieval of the whole episode upon seeing the first target should boost activity of the second associated target, which should compensate for any inhibition of attention following encoding of the first target. The employment of attention can in turn lead to enhanced processing of the second target, leading to its encoding in memory and making its representation consciously accessible for later reporting of the target's identity.

Building on the premise that familiar images typically possess more robust and detailed neural representations compared to unfamiliar ones (Jackson & Raymond, 2006; Martens and Gruber, 2012), we further hypothesized that learnt scenes would be detected with a higher degree of accuracy than new scenes within the RSVP task (Hypothesis 2). This expectation stems from research indicating that stronger and more accurate memory representations can better guide attention (Williams et al., 2022) or are more likely to survive the attentional blink effect (Jackson & Raymond, 2006). Previous learning of the images, bolstered by the imagination task, is likely to foster the creation of highly detailed neural representations of these scenes. These enhanced representations should, in turn, facilitate quicker and more accurate identification of the scenes amidst the RSVP stream. Conversely, new scenes, which are shown for the first time and only fleetingly within the stream, may lack this advantage due to the absence of pre-existing memory representations. They may thus offer weaker guidance for attentional selection, resulting in poorer detection performance. The use of new images as T2 further serves as a control measure to assess the influence of prior learning on performance within an RSVP task.

By manipulating the second target, all the rest being equal, the experiment aims to explore how processing efficacy of the second target is affected by memory retrieval processes. More broadly, it constitutes a first step in shedding light on the dynamics of episodic memory and its interaction with selective attention and perception.

Methods

Participants

In line with the preregistered study plan (https://osf.io/wsqy3), the sample included data from 52 participants (25 women). Twenty-four undergraduate Psychology students at the University of Groningen (12 women) and twenty-eight students enrolled via the Prolific platform world-wide (13 women) took part in the study in exchange of course credits or $9 payment, respectively. All participants had advanced proficiency of the English language and gave their informed consent to partake in the study. The sample was composed of individuals within an age range of 18–35 years and who reported having normal or corrected-to-normal visual acuity.

Four participants were removed and replaced after meeting our preregistered exclusion criteria, being (i) extremely low performance in the learning phase, defined by a score that is two standard deviations below the total mean and/or performance at chance level (i.e., <.25, given four response options); (ii) extremely low accuracy when reporting T1 in the RSVP phase, defined by a score that is two standard deviations below the total mean and/or performance at chance level (i.e., <.125, given eight response options).

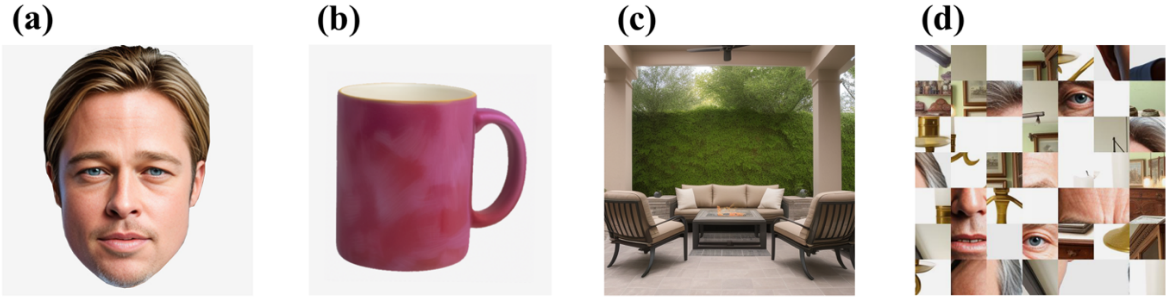
Apparatus and Stimuli

The experimental software was purpose-written in JavaScript (React framework) and was executed online inside a browser on participants' desktop computer (https://giuliaq.com/engram/). The software screened out participants using mobile devices and those with screen resolution of less than 1366 pixels by 768 pixels.

Before the execution of the main experiment, we conducted two pilot studies to refine our stimuli and instructions. These preliminary tests played an essential role in optimizing the experimental manipulation and ensuring its effectiveness. Detailed results from these pilot studies, along with the consequent modifications made to fine-tune our experimental design, are presented in Appendix A. The final version of the experimental stimuli encompassed a set of 200 AI-generated images of famous faces, everyday objects, and locations created using the Stable Diffusion's generative AI algorithm, as well as 200 scrambled images (see Figure 1). All images were generated in a square format sized 512x512 pixels. To create a set of famous faces, a selection of celebrities used by Horner and Burgess (2013), in addition to the most popular celebrities at present counterbalanced by sex and ethnicity, was fed into the Stable Diffusion algorithm using the X/Y/Z script. Parameter settings and prompts used (see Appendix B) ensured that the AI-generated images were consistent in terms of lighting and quality, were taken from the front view, and had a white background. A similar procedure was followed for the location and object images, which constituted a set of unique locations (outdoor and indoor) and objects. A quality-control procedure was followed to ensure all images were optimal in terms of being recognisable and devoid of aberrations such as missing (or extra) parts. Images of faces were consequently cut in Photoshop to remove the neck and parts of the hair to fit into an ovoid shape to minimise distraction caused by irrelevant details (e.g., hairstyle) and standardise the images.

Figure 1

Examples of Face (a), Object (b), Location (c), and Scrambled (d) Images Used in The Study



Sixty images were utilized in the learning phase of the experiment, comprising twenty faces, twenty objects, and twenty locations. These were randomly assembled into twenty distinct sets, each consisting of one face, one object, and one location. The resulting 20 sets of images were kept constant and presented identically to all participants, ensuring that each participant was exposed to the same events. For the RSVP phase, all images from the learning phase served as targets, together with 40 novel images of locations. These novel images maintained conceptual distinctiveness, precluding any overlap in content from the target locations. The remaining 100 images, out of 200, were employed to fill the response options for the recognition tests and for the practice trial.

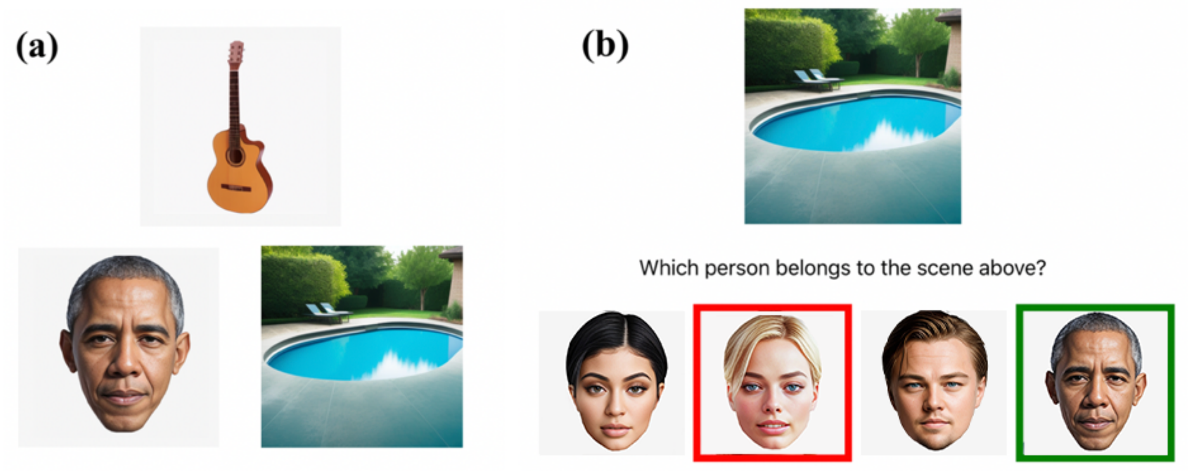
Two-hundred scrambled images served as distractors for the RSVP task, featuring a scrambled 7x7 composite of one face, object, and location. The distractors' design incorporated both low-level (i.e., feature-based) and high-level (meaning-based) attributes, due to the presence of both clusters of colours and line orientations and complex elements such as face or object parts (e.g., eye). This approach was theorised to leverage the strengths of both conceptual and perceptual masking as outlined in Maguire & Howe (2016), making it particularly effective given the inter-stimulus interval of 110 ms between the onset of successive images. Based on the outcomes of the pilots, the resulting “hybrid masking” afforded by scrambled distractors effectively obscured target images of faces, objects, or locations, achieving the goal of eliciting an AB effect for all target types.

Design and Procedure

The study consisted of a learning phase, an RSVP phase, and two cued-recognition tests (one preceding and one following the RSVP phase). During the learning phase, participants were exposed to 20 distinct sets of images, each containing a face, an object, and a location. These sets were presented in a randomized order, with each set being displayed for a duration of 20 seconds. For each set, the three images were scaled down to 400x400 pixels and presented in a triangular configuration, with the object image occupying the top position and the face and location images placed on the two sides (Figure 2a). Participants were asked to vividly imagine a story between the face, the object, and location, as if they were witnessing the event from their own point of view. Following the learning phase, a cued-recognition task was used to probe participants' newly formed memories for the twenty events. Given the image of one of the 20 locations (cue), participants had to choose which face and which object corresponded to the same event as the shown location among four options (see Figure 2b). Upon clicking, a green frame appeared around the correct option while a red frame signalled the incorrect option, if selected.

Figure 2

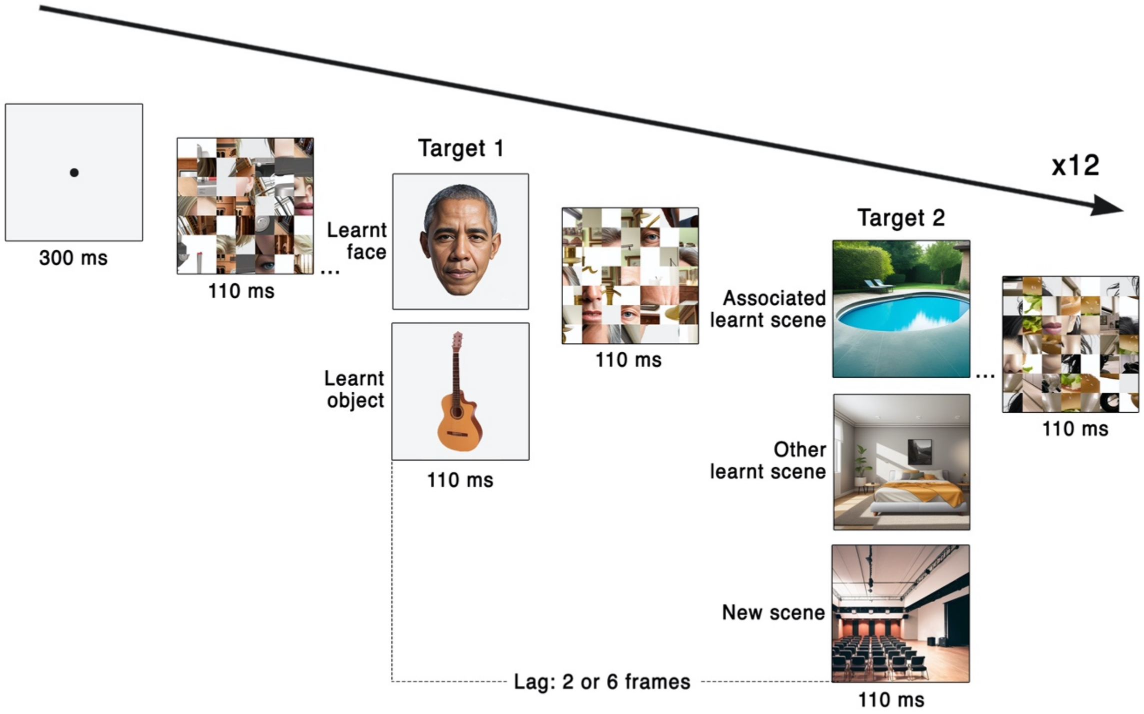
Example of Typical Imagination Trial (a) and Cued Recognition Task (b)



The RSVP phase (Figure 3) included a total of 160 trials, preceded by a short training run of four trials and a 5-minute break after 80 trials. Following a brief countdown screen (3 s) and a central fixation dot (300 ms), participants viewed a stream of 12 images (scaled to 400x400 pixels), each shown for 110 ms. Their task was to look for the image of a face or object (Target 1) and the image of a location (Target 2) among the scrambled images. The interval between the onset of the two targets (i.e., lag) could be either two frames (Lag-2, equivalent to 220 ms) or six frames (Lag-6, equivalent to 660 ms), with scrambled images serving as intervening distractors. While the first target was always a face or object drawn from the 20 learnt events, the second target (T2) could either be a learnt location associated with the first target (Associated-T2), a learnt location not associated with the first target (Other-T2), or a novel location (New-T2). Each possible combination of Lag and T2-Type conditions was repeated 20 times and their order was fully randomised across 120 trials. Unbeknownst to participants, 40 out of the total 160 trials did not contain the second target (i.e., "catch" trials). This was done to detect possible response biases when no target is seen (see Analysis section).

Figure 3

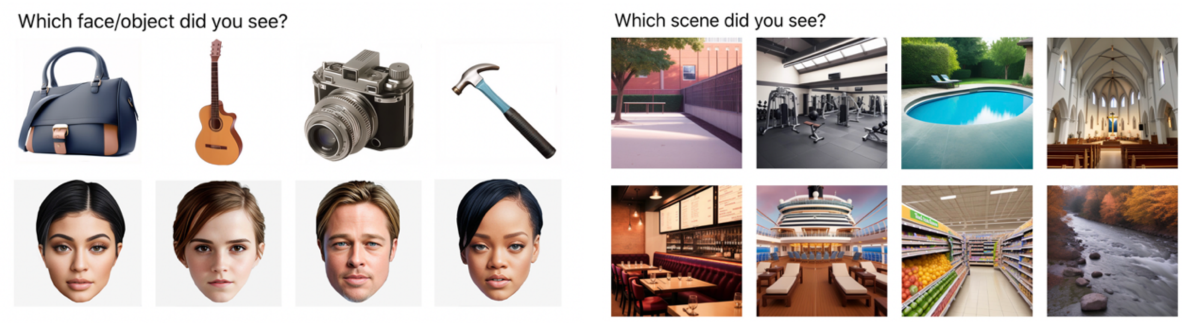
Diagram of RSVP Trial Sequence Depicting Conditions for T1-Type (Faces Vs Objects), T2-Type (Associated, Other, New), and Lag (Lag-2 Vs Lag-6)



Following each RSVP stream, participants could report which targets they saw by selecting one of eight options (one screen for Target 1 and one screen for Target 2; see Figure 4). They were encouraged to do so as accurately as possible and to select a random option if they missed one or both targets. For Target 1, participants could choose from four learnt faces and four learnt objects. For Target 2, response options were composed of four new locations and four learnt locations, randomly shuffled. Each set of eight response options featured conceptually-distinct types of locations and objects with no repetitions (e.g., no two images of swimming pools), demanding specificity in participants' selection. Among the response options, the critical target location associated with the first target was shown 50% of the times despite not being part of the RSVP stream. This was done to ensure that the associated location option was not only present in trials where it was the second target, hence reducing the chances of a systematic response bias for the critical associated target. At the end of all RSVP trials, a final cued-recognition task was performed to test memory for the 20 events. Upon completion of the experiment, participants were required to respond to a series of eight questions, designed to gather data on their experience during the experiment and their perceptions of the quality of the stimuli presented. Overall, the experiment took between 40–45 minutes to complete.

Figure 4

Recognition Test for Target 1 (Left) and Target 2 (Right) Following Each RSVP Trial



The RSVP experiment constituted a within-subject 2x2x3 design with twelve main conditions, consisting of all possible combinations of two lags (220 ms and 660 ms), two types of T1 (faces or objects), and three types of T2 (Associated, Other, and New). The dependent measure of interest was accuracy for correctly selecting the first and second targets. Two additional “catch” conditions, in which no T2 was shown, were included to control for response biases. This resulted in a total of 14 conditions (2 T1-Type x 3 T2-Type x 2 Lag + 2 T2-Absent).

An important experimental consideration was ensuring that each of the 60 images from the learning phase would serve as a target in the RSVP task at least once, without any image being over or underrepresented in a particular condition. Any such repetition could introduce more variability in the data due to stimulus-specific or learning effects, potentially confounding any effect of Lag or T2-Type. To address this, an image allocation strategy was adopted to ensure uniform representation of T1 and T2 images across experimental conditions. Each participant was exposed to image triplets from 10 of the 20 learned events under one Lag condition, and to the other 10 events at the other Lag condition. This allocation was fully counterbalanced across the participant pool to eliminate any effects tied to specific stimulus characteristics within a given condition. As a result of this allocation strategy, each associated T1-T2 pair was shown only once, circumventing any undue learning effect of seeing the same pair of images twice. To further ensure equal exposure of images between associated and non-associated T2 conditions, each of the twenty learnt T2-locations was displayed exactly four times: twice under the Associated-T2 condition (once paired with a T1-face and once with a T1-object), and twice under the Other-T2 condition. In contrast, new location images were shown only once to preserve their novelty.

Data Analysis

In the RSVP task, manipulations were made to the number of intervening frames or lag between the two targets, the type of T1 and T2 used, and whether the T2 was presented. The outcome variable of interest was the response accuracy for accurately reporting T2. For each participant, the proportion of correct responses for reporting T2, excluding trials in which T1 reporting was incorrect, was calculated from 120 trials and split by Lag and T2-Type. In the main confirmatory analyses, T1-faces and T1-objects conditions were considered jointly by taking their average for different Lag and T2-Type conditions. This resulted in 6 proportions (2 Lag x 3 T2-Type).

Confirmatory analyses involved a 2x3 repeated-measures ANOVA (rm-ANOVA), with the two within-subject factors being Lag (with two levels: Lag-2 and Lag-6) and T2-Type (comprising three levels: Associated, Other, and New). The dependent variable in the analysis was T2 accuracy. To further investigate the hypothesized interaction between Lag and T2-Type conditions (Hypothesis 1), two planned contrasts were performed in accordance with the study's preregistration. The first contrast compared the difference in AB magnitude between Associated-T2 and Other-T2 conditions, which was expected to be greater for the latter condition. The second contrast compared the difference in AB magnitude between learned T2s (associated and non-associated) and new T2s. To test our second hypothesis, a contrast was conducted in which performance on learnt T2s was compared with performance on new T2s.

As per pre-registration, T2 accuracy data was corrected for potential response bias. For each participant, a correction factor was calculated for each condition using the trials without T2. The expected selection frequency of each options group (associated T2: 1/8, other T2: 3/8, new T2: 4/8) was divided by the respective observed selection frequency, giving a correction factor. In cases where a bias toward over-choosing the T2 option was identified (e.g., correction factor < 1), the participant's T2 accuracy score for the condition was multiplied by the correction factor, with a maximum product of 1. For example, if a participant had an observed selection frequency for the Associated-T2 options of 1/6, which has an expected selection frequency of 1/8, a correction factor of 0.75 would be multiplied with the accuracy scores for Associated-T2 conditions.

The statistical significance criterion for both the rm-ANOVA and follow-up contrasts was set at $p < .05$. One-tail tests were applied for each contrast, in line with the hypothesized pattern of results (i.e., smallest AB effect for associated T2 and largest AB effect for new T2). All analyses were conducted using Python and JASP (Version 0.14; JASP Team, 2020).

Results

Learning Performance

Accuracy on the cued recognition test for the 20 imagined scenarios was close to ceiling, with 96% correct responses (*SD* = 7%) on the first round of testing prior to the RSVP task and 97% correct responses (*SD* = 6%) on the second test following the RSVP. These results indicate that most (if not all) scenarios were appropriately encoded – given high performance immediately after learning – and their memory was retained throughout the experiment (~40 minutes). High performance on the second cued recognition test further shows that the memory for the scenarios was not affected/degraded by taking part in the intervening RSVP task.

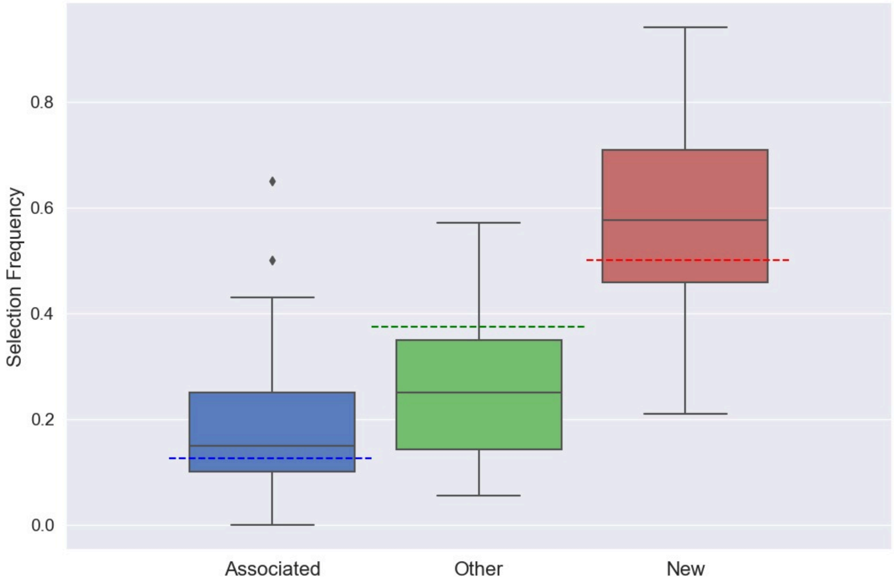
Response Bias Check

The response bias analysis showed that for the T2-absent trials, on average, there was a small over-selection of Associated-T2 options, an under-selection of Other-T2 options, and an over-selection bias for New-T2 options (Figure 5). The mean observed frequency for

Associated-T2 options was .18 (.065 above expected), for Other-T2 options .24 (.13 under expected), and .58 for the New-T2 options (.08 above expected). It is worth noting that the data for the Associated-T2 options may be skewed by the presence of two outliers. T2 accuracy scores for each participant were adjusted with individual correction factors.

Figure 5

Boxplot of Observed Selection Frequency for T2-Absent Trials for Associated-T2, Other-T2, and New-T2 Response Options. Dotted Lines Represent the Respective Expected Selection Frequencies (.125, .375, and .5)



Questionnaire Data

Ratings on a 5-point scale are included in Table 1 as a general indication of the quality of participants' performance on the imagination task and the RSVP phase and their attitudes toward the images used and the experiment. Overall, it appears that participants were able to vividly imagine the events as if they were experiencing them from their own point of view (Items 4–6), with items scoring between 4.1–4.6 (*SD* = .78–1.0). A sub-section of the total sample (*n* = *28*) endorsed that they tended to focus on finding images they had previously imagined in the RSVP task (Item 7b), with a medium-high average score of 4.3 (*SD* = .78).

Table 1

Ratings (1-5 Scale) for Imagination Task, Stimulus Quality, and Approach on Task (With M = Mean and SD = Standard Deviation)

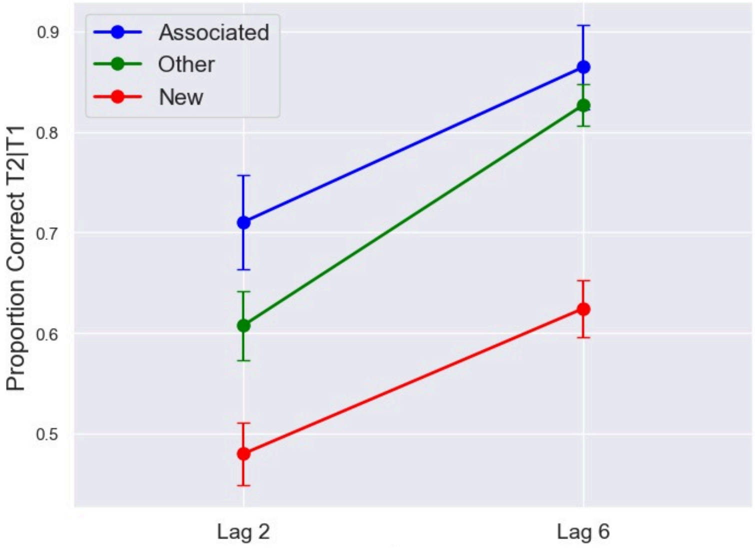
Question	**M**	**SD**
1) The images used in the experiment were of good quality.	4.86	.40
2) I could recognise many/most of the famous people shown in the experiment.	3.88	.97
3) Overall, all images looked as “real” as photographs.	3.82	.01
4) Seeing the images helped me form visual images in my mind.	4.59	.57
5) I could imagine the events vividly and in great detail.	4.26	.78
6) During the imagination task, it was like as if I was observing the event from my own point of view.	4.06	.97
7a) Instructions were clear and left me with no doubt about what to do (*n* = 24).	4.46	.66
7b) During the rapid search task, I tended to focus on finding images I had previously learnt/imagined (*n* = 28).	4.3	.76
8) Overall, I enjoyed taking part in the experiment.	4.28	.92

Confirmatory Analyses (RSVP Task)

During the RSVP phase, participants correctly identified T1 targets 92% of the time (*SD* = 10%), with comparable performance for T1-faces (*M* = 93%, *SD* = 10%) and T1-objects (*M* = 91%, *SD* = 11%). A repeated-measures ANOVA was performed on T2-accuracy data for the 120 trials containing the second target, excluding those trials on which the T1 was not correctly identified (in line with preregistration). As the assumption of sphericity was violated, a Greenhouse-Geisser correction was applied. The results yielded significant main effects of Lag, *F*(1, 51) = 69.23, $p < .001$, $\eta^2_p = .58$, and T2-Type conditions, *F*(1.08, 55.04) = 8.55, $p = .004$, $\eta^2_p = .15$. Furthermore, a significant interaction effect was found between the Lag and T2-Type factors, *F*(1.9, 96.80) = 3.51, $p = .036$, $\eta^2_p = .06$. Therefore, the time between targets (Lag) and the type of relationship the second target held with the first target (T2-Type) significantly affected accuracy in reporting T2, with the AB effect varying depending on the T2-Type. Figure 6 depicts a visualisation of the results, showcasing the interaction effect between T2-Type and Lag factors.

Figure 6

Line Plot of T2 Accuracy (Proportion T2 Correct Given Correct T1) by Lag and T2-Type – With Error Bars Depicting Standard Errors of the Mean



The interaction between Lag and T2-Type (Hypothesis 1) was further investigated by conducting follow-up paired-sample t-tests on the differences in T2 accuracy from a longer to a shorter lag (i.e., AB magnitude) for different conditions. The one-tailed tests compared (a) learnt associated and non-associated T2s and (b) learnt and new T2s. The comparison between associated and non-associated T2s revealed a significant difference in AB magnitude, *t*(51) = 2.4, $p = .01$, $d = .33$. Specifically, the average drop in T2 accuracy when moving from a longer to a shorter lag was 22% (*SE* = 3%) for learnt non-associated T2s, compared to only a 15% decrease (*SE* = 3%) for associated T2s. This supports the first hypothesis that associated T2s would produce a smaller AB effect than learnt non-associated T2s, with higher T2-accuracy at Lag-2 (and a smaller AB effect) when the two targets in the stream are part of the same episode compared to when these are unrelated.

Conversely, the one-tailed paired-sample t-test of the difference in AB magnitude (i.e., Lag-6 minus Lag-2) between learnt and new T2s did not reach significance, $t(51) = 1.44$, $p = .92$, $d = .2$. Thus, performance decline at Lag-2, attributed to AB, shows a similar degree of severity for both learnt and new T2 conditions. We therefore looked at whether a difference in overall performance could be found between learnt and new conditions independently of Lag, testing our second hypothesis. A contrast was performed to compare performance on learnt T2s (both associated and non-associated) with performance on new T2s. Results indicated a significant difference between learnt and new conditions, $t(51) = 5.63$, $p < .001$, $d = .78$. Overall, learnt T2s were correctly identified 75% (*SE* = 3%) of the times, against 55% (*SE* = 5%) correctly identified new T2s. In other words, participants' recognition performance was worse for new T2-scenes compared to learnt T2-scenes. This evidence supports our second hypothesis that new T2-scenes would be particularly challenging to detect, regardless of their serial position in the RSVP stream.

Exploratory Analyses

Cued recognition performance to test memory for the 20 imagined events, given the image of the scene as a cue, was compared for faces and objects. Performance for face-scene and object-scene associations was comparable across the two memory tests, averaging 95–97% correct (*SD* = 7–9%) for faces and 97% correct (*SD* = 6%) for objects.

As part of additional exploratory analyses, we considered potential differences in RSVP performance when presented with either objects or faces as the first target. The accuracy for T1 recognition for these two kinds of stimuli was comparable, with a mean proportion of correct responses of .93 (*SD* =.1) for T1-faces and .91 (*SD* = .11) for T1-objects. A rm-ANOVA was performed on T2 recognition performance, conditional on the type of T1 used. The Greenhouse-Geisser correction was applied due to violations of the sphericity assumption. The three-way interaction between T1-Type (objects vs faces), T2-Type (Associated, Other, and New), and Lag (Lag-2 vs Lag-6) did not reach significance, $F(1.93, 98.44) = 2.76$, $p = .07$, $\eta^2_p = .05$. Although the data did not reach threshold for statistical significance, the results hinted at a possible variation in the combined effect of the three independent variables on T2-accuracy (see Figure 7). While acknowledging that caution is needed in interpreting such results, we nevertheless opted to probe these interactions further, given their potential theoretical relevance.

Figure 7

Line Plots of T2 Accuracy by Lag and T2-Type for T1-Faces (Left) and T1-Objects (Right) – With Error Bars Depicting Standard Errors of the Mean

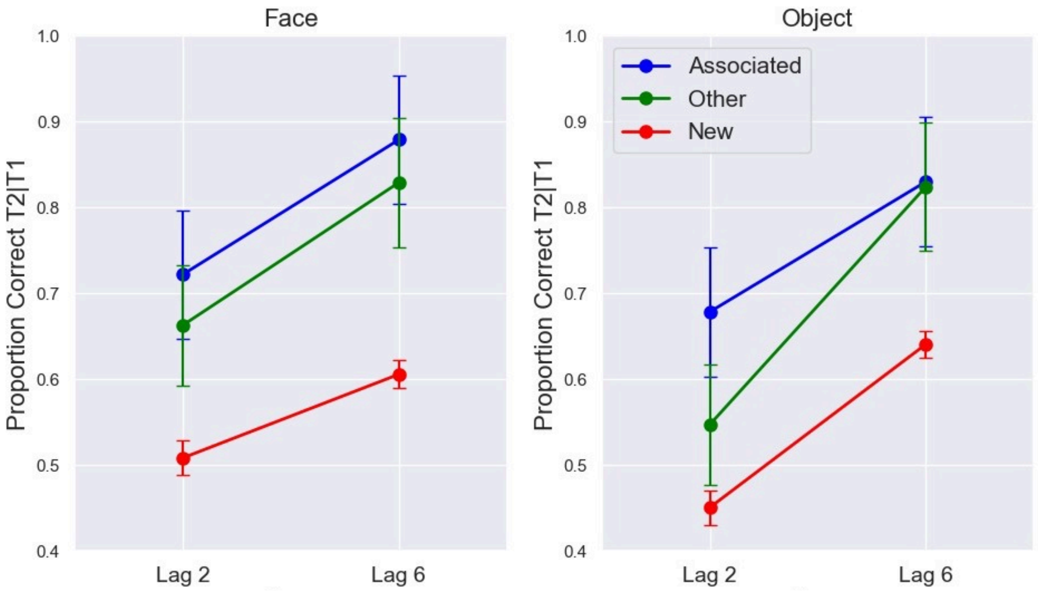


Table 2 shows AB magnitude data conditional on T2-Type and T1-Type. Follow-up paired-sample two-tailed t-tests showed significant differences in AB magnitude across different T1 conditions for the T2-New condition, *t*(51) = 2.21, *p* = .03, *d* = .3, and Other-T2 condition, *t*(51) = 3.31, *p* = .002, *d* = .46. No significant difference in Lag conditional on T1-Type was found in the T2-Associated condition, *t*(51) = .12, *p* = .9, *d* = .02. The results indicate that there was a larger attentional blink effect at Lag-2 when using T1-objects instead of faces for new and learnt non-associated T2s. Conversely, an attentional blink of comparable magnitude was found for associated T2s for T1-faces and T1-objects. Although these exploratory follow-up tests suggest that reporting T2 at a short lag may be improved when using T1-faces compared to T1-objects, these findings emerged from an initial three-way interaction that did not reach statistical significance. Consequently, while these insights are potentially valuable, they should be interpreted with caution and are indicative rather than conclusive, highlighting areas for further research validation.

Table 2

Mean Differences Between Lags Conditional on T2-Type and T1-Type (With Standard Deviation in Brackets)

	T1-Faces	**T1-Objects**
T2-Type	**Lag-6 minus Lag-2**	**Lag-6 minus Lag-2**
Associated	.16 (*.26*)	.15 (*.23*)
Other	.17 (*.23*)	.28 (*.24*)
New	.10 (*.29*)	.19 (*.21*)

Discussion

The present study builds and expands upon previous work focusing on the rapid and automatic stage of episodic memory retrieval (Schultz et al., 2022; Waldhauser et al., 2016), encompassing to the cortical re-activation of memory traces of past events. We posit that this process can exert considerable influence on the manner in which new information is encoded and perceived. The results from the experiment demonstrate that (i) a second target that is part of the same learnt event as the first target is more likely to be perceived and to survive the AB; and (ii) learnt targets are more likely to be detected overall than new targets. There is therefore strong evidence that the content of episodic memory influences the selection, perception, and consolidation of new information within a short time window (i.e., 110–220 ms), and that new information is harder to perceive compared to information that is part of one's memory.

Ecphory Facilitation in the Attentional Blink

The results of the current study support our first hypothesis that associated T2s would produce a smaller AB effect than learnt non-associated T2s (see Figure 6). In other words, participants showed higher T2 accuracy within the critical AB window when the two targets in the stream were part of the same episode compared to when these were unrelated. According to de Jong et al. (2007), manipulating the second target can provide insight into how it is processed, as evidenced by changes in the AB effect. The smaller AB effect that was found for associated scenes, compared to non-associated scenes, can therefore be attributed to more efficient processing of the T2 when this is part of the same event as T1. This finding supports the notion that ecphory occurs exceedingly fast (Waldhauser et al., 2016), given that its effects on T2-processing could manifest at a short lag (220 ms). It further underscores the incidental nature of recollection, as the retrieval process was initiated upon brief exposure to the first target, even without instructions to recall associated elements.

Within the diverse array of theories surrounding the attentional blink (Martens & Wyble, 2010), the Episodic Simultaneous Type/Serial Token (eSTST) model by Wyble et al. (2009) stands out for its comprehensive nature in accounting for several AB phenomena (Bowman et al., 2008; Spalek et al., 2012). In its essence, the model posits that the visual system strives to preserve the temporal order of successive stimuli for better encoding, together with their identity. While working memory is encoding the first target in the stream, the deployment of attention toward upcoming stimuli is temporarily suppressed, resulting in a temporary attentional blink. This mechanism theoretically serves the function of ensuring that non-consecutive information is parsed into different attentional episodes, allowing enough time for previous information to be fully processed and recorded in memory.

In the context of our study, the eSTST model provides one robust account to frame the advantage in perceiving associated T2s over non-associated targets. Seeing the first target (face or object) should activate memory traces of related elements associated with the event, leading to a swift pattern completion process. Ecphory-related re-activation, together with activity in response to seeing the actual T2, may counteract the attentional inhibition caused by the processing of the first target and lead to a “re-opening of the attentional gate”. Once the threshold is reached for re-engaging attention, attention would further promote perception of the associated T2-scene by boosting its activation until it crosses threshold for encoding. This way, associated T2s would gain an advantage in processing and mitigate the attentional blink effect, in contrast to non-associated T2s that do not benefit from such processing facilitation.

An alternative explanation is that attention remains inhibited during the processing of the first target, but the mnemonic association between targets is sufficient to ease the encoding of the second target. Similar to how a semantically-related target is more likely to be identified due to prior semantic priming by another target (Potter et al., 2005, Juola et al., 2000), associated second targets in our study may also benefit from their relation to the first target. As the first target sets off a pattern completion process that pre-activates associated elements, it may make the associated second target more distinct and lower the threshold for its encoding or tokenization (Juola et al., 2000). This pre-activation might thus enhance the chances that the target is fully encoded and later reported, even in the context of inhibited attention.

Both explanations offer valuable perspectives on the processing and encoding of associated targets. While both accounts are plausible and rely on the quick and incidental memory reactivation of associated items from a partial cue, further research is needed to determine which one accurately represents the underlying processes. Specifically, it has to be more firmly established whether the benefit of seeing associated targets can be ascribed to the involvement of attention in processing the second target, or whether it is exclusively related to ecphory enhancing target processing. For example, future investigations could consider employing neuroimaging studies to discern the neural correlates of attention or memory retrieval, shedding light on this issue.

Learnt-Over-New Advantage in Perception

Overall, recognition performance with new T2-scenes was markedly worse than performance with learned T2-scenes, both associated and non-associated (see Figure 6). Consistent with our second hypothesis, this result suggests that new targets are more difficult to perceive, irrespective of where they appear in the RSVP sequence. That is, even at the end of the AB period, with targets 660 ms apart and no expected attentional blink effect, response accuracy for new targets remained the lowest. The result raises important theoretical questions as to why performance for new targets remains relatively poor throughout the experiment. To account for this, we propose two potential explanations.

The first explanation relates to a top-down mechanism geared toward prioritizing learnt items while actively inhibiting new ones. After the learning/imagination tasks, participants may expect to see the learnt items again in the RSVP task. Assuming that only learnt targets will appear may be especially justified, given that the first target is always a learnt item. Furthermore, learnt T2s constitute 2/3 of all experimental trials (excluding T2-absent trials), a statistic that may be implicitly picked up by participants (Christiansen, 2019). They may thus internally choose to focus on detecting learnt images as a search strategy, even when the task does not involve seeking learned targets. The resulting top-down attentional control setting may predispose the system towards learned images over new ones, with rapid familiarity judgments possibly aiding in this discrimination (Park et al., 2010; Xu et al., 2018). Under the eSTST model, new targets may be actively inhibited for not matching the arbitrary attentional control setting geared toward learnt images, receiving the same treatment as distractors (Wyble et al., 2009). Such an inhibitory mechanism could explain the persistently low performance for the new T2s found in our experiment (55% correct), which is 20% lower than that for learnt T2s (75% correct).

In an effort to further investigate this possible search strategy, participants were asked whether they consciously looked for previously learnt images in the RSVP task. The average score was relatively high at 4.3 out of 5, suggesting that participants may indeed have been actively searching for familiar items. However, the reliability of this self-report is limited, as it was based on a single question. The conscious focus on previously learnt images could be a significant factor in their prioritization and deserves further exploration in future studies, for instance, by employing more nuanced self-report measures on participants’ search strategies.

A second explanation for the poor performance with new T2s is that the inherent familiarity of learned images provides a perceptual advantage, eliminating the need for active inhibition or top-down control. In our study, each new scene was presented only once in the RSVP, while each of the twenty learned scenes was repeated twice in the stream, plus another two times during the learning phase. Repeated exposure to learned scenes likely results in the fine-tuning or sharpening of their neural representations (Wiggs & Martin, 1998), leading to a priming effect that makes these images easier to perceive.

Stemming from the learning experience itself, including the imagination task, familiar images may further possess a more robust and sharper neural representation than new images (Martens and Gruber, 2012; Jackson and Raymond, 2006). The higher quality or representational fidelity of the learnt scenes may have caused these to bias attention more than new scenes, following Williams et al.'s (2022) findings that images high in representational fidelity are most likely to guide attention. The remarkably high memory performance for the learnt events, with correct recollection of the twenty events 97% of the time, strongly corroborates the presence of a well-established memory representation for all learnt items. This level of memory performance stands in contrast to the new scenes briefly presented in the RSVP stream for only 110 ms, which presumably lack sufficient exposure to establish robust memory representations.

The differential representation between old and new images, as well as priming effects, might have jointly contributed to the observed performance advantage of learned scenes over new ones in the RSVP task. These bottom-up mechanisms would operate irrespective of top-down task requirements or participant expectations, speaking to the fundamental influence of past learning experiences on perception.

The performance advantage for learnt (versus new) targets is remarkable, implying that we are much better at perceiving familiar stimuli compared to new ones. Both top-down and bottom-up mechanisms may be at play in giving rise to this performance difference, possibly interacting with one another. Further investigation is needed to more clearly elucidate the root cause of the reduced performance for new T2-scenes, and to conclusively distinguish between the top-down and bottom-up explanations. For instance, incorporating a 'semi-new' condition, wherein participants are initially exposed to a set of scenes that are later presented in the RSVP, could help measure the influence of familiarity on perception. By comparing the performance on these 'semi-new' scenes with truly new scenes, which appear in the RSVP for the first time, the differential effect of familiarity on perception could be elucidated. Another potential improvement involves presenting new images as frequently as learned images to make the conditions more comparable and rule out low-level priming effects. Ultimately, these additional measures can deepen our understanding of the interplay between learning and perception in the attentional blink effect.

Performance for T1-Face Versus T1-Objects

Two categories of stimuli, faces and objects, were incorporated as first targets in the RSVP task. This experimental design allowed us to examine whether the effects of episodic retrieval are consistent across distinct categories of stimuli used as retrieval cues. If pattern completion and recollection are truly all-or-none phenomena (Joensen et al., 2020), any learnt stimulus should be able to re-activate the full memory of the event, regardless of its category. While our primary finding of an attenuation of the AB for associated targets appeared to be more evident when using objects as T1 instead of faces (see Figure 7), this difference did not reach the $p<.05$ threshold of significance ($p = .07$). Nonetheless, we chose to further explore this aspect, keeping in mind the tentative nature of these results.

One explanation to account for this difference is that images of faces may be processed more efficiently than images of objects. Faces are found to possess “pop out” properties in visual searches tasks (Hershler & Hochstein, 2005), possibly due to our expertise as humans with processing faces (Bukach et al., 2006). Their coherent global structure may particularly stand out against more heterogeneous distractors in a RSVP stream (Landau and Bentin, 2008), making them easier to detect. Given that our scrambled distractors also display a level of heterogeneity, it is plausible that faces stood out in this context as well.

More efficient T1 processing should lead to an attenuation of the attentional blink (Chun & Potter, 1995; Juola et al., 2000), as shorter processing duration would end attentional inhibition sooner and promote full processing of the second target. In line with this, we found evidence of a reduced AB effect for all non-associated T2 conditions (New and Other) when T1 are faces rather than objects. Conversely, no difference in AB was found in the associated T2 condition when using different T1-types. It follows that faster T1 processing could lead to a general uplift in performance in non-associated conditions. This performance boost, however, might mask the distinct advantage of seeing an associated target in the stream, making it stand out less than when using objects as first targets.

Another explanation is that, during retrieval, the pairwise association between objects and scenes might be stronger than the association between faces and scenes. If stronger object-scene associations were indeed formed during learning, a T1-object would trigger a more robust activation of the associated scene in the RSVP task. This could in turn provide the associated scene with a significant advantage during the attentional blink phase, while making performance for non-associated scenes appear relatively low. However, no differences in memory performance were found that could support differential associative strength between faces and objects and their related scene. Both types of stimuli performed near ceiling and appeared to be well-encoded and retained. These results, however, should be interpreted with caution due to the design of the cued-recognition task. In the task, each scene was shown consecutively twice as a cue, first requiring a match with the correct object and then with the correct face. Consequently, we cannot dismiss the possibility that high performance in recognising face is influenced by the previous recollection of objects, which could trigger pattern completion and make the related face easier to recollect.

The idea that more efficient T1-processing can account for the performance difference based on the type of T1 used seems probable, as suggested by the attenuation of the AB for non-associated targets. However, it remains inconclusive whether differences in the strength of associations between item types may also contribute to this phenomenon. As we look forward, there are several potential avenues for refining the current experimental design to validate our conclusion further. For instance, future studies could benefit from employing more effective distractors for faces, such as using other faces. This adjustment could make face processing more challenging, potentially making any improved performance for associated targets more evident. Additionally, modifying the cued-recognition task to ensure randomness in the order of testing could provide further insight. This change would allow us to measure the strength of associations between different types of stimuli more accurately, without the recollection of one pair influencing the recollection of the other pair. Through such enhancements in the experimental design, we can continue to refine our understanding of the mechanisms underlying episodic retrieval and its association with target processing and stimulus type.

Cross-Category Attentional Blink Effect Using Familiar Faces

Our research significantly contributes to discussions regarding the occurrence of the attentional blink effect across diverse semantic categories of targets. A puzzling aspect of our findings is the observed AB effect when using famous faces as T1, especially considering assumptions that familiar faces are processed faster or are less attentional demanding than unfamiliar faces (Jackson & Raymond, 2006). Our findings further challenge the results of Landau and Bentin's (2008) study, who reported an absence of the AB effect when images of faces were used as T1 and the second target-image was from a different semantic category. This contradiction stands out especially in light of the high T1-face detection accuracy (93%) in our study, even as Landau and Bentin (2008) linked their lack of AB effect to the ease of identifying T1 faces. If encoding of familiar faces is indeed more efficient and takes up fewer processing resources and time, it should circumvent the processing bottleneck that typically leads to an AB (Chun and Potter, 1995). Yet, the presence of an AB effect in our study suggests that, even for familiar stimuli, some attentional resources may be needed for encoding. This finding appears to resonate with Shapiro et al.'s (1997) results, who found that even participants' own names, a highly salient stimulus, triggers a standard encoding process that inhibits attention for a consequent target, when used as T1. Despite the consistent AB effect taking place with face stimuli, however, this was still less pronounced than with T1-objects, indicating that faces may be still be easier to process compared to objects. Therefore, our results indicate that faces can indeed trigger a cross-category AB effect on scenes, although not as severely as objects do. They further challenge traditional assumptions regarding the automaticity of processing familiar faces.

Future Directions

The study provides compelling insights into the interplay between temporal attention and rapid episodic retrieval processes. A possible future line of research could focus on the neural basis of episodic memory retrieval within a RSVP task, specifically, how associated elements influence perception. Identifying the neural signatures associated with rapid recognition of stimuli linked to previous events could have wide-ranging applications, such as enhancing techniques used in lie detection investigations. Using EEG, Bowman et al.

(2013) established a potential method for detecting concealed information. They found a distinct pattern of brain responses when participants were presented with their names, even as they attempted to actively conceal their identity. Future research could explore whether a comparable neural reaction occurs for complex visual stimuli, such as the images of faces, objects, and scenes used in the present study. Such an investigation would move this line of inquiry closer to real-world scenarios, reflecting the primarily visual nature of autobiographical memories.

While our study primarily focused on the facilitation in perception of target information consistent with past experience, future investigations could probe the potential influence of episodic retrieval on attentional capture. Prior research conducted by Giammarco et al. (2016) has begun to explore the potential link between episodic memory and attentional capture, although their main focus was on which memory system maintains target templates for performing the task. To delve deeper into the after-effects of episodic retrieval on consequent perception, future studies could examine whether viewing a learnt distractor-item in the RSVP stream automatically triggers a retrieval process and how this retrieval alters the processing of subsequent targets. Due to the automatic nature of ecphory and pattern completion, as observed in our study, the retrieval process triggered by a distractor should occur even without instructing participants to look for target-items related to previous learning. This line of inquiry could have profound implications for understanding conditions such as Post-Traumatic Stress Disorder (PTSD), characterized by recurrent, intrusive recollections of traumatic events that cause significant interference with ongoing cognitive and attentional processes (American Psychiatric Association, 2013). It would further advance our understanding of the interplay between incidental episodic retrieval and attentional processes.

Conclusion

The thesis explored the intersection of episodic memory retrieval and perception within the context of the attentional blink paradigm. The findings make a compelling case for a robust interaction between episodic memory and perception, underscored by the advantage in perceiving targets that were part of learnt events compared to non-associated ones. This advantage likely stems the rapid and incidental re-activation of memory traces, leading to enhanced processing of retrieved information and the potential involvement of attention. The research further unveiled a consistent 'learnt-over-new' advantage in perception, with learned targets recognized more proficiently than new ones across all experimental conditions. This persistent effect invites further inquiry into the mechanisms at play – potentially top-down prioritization of learned items, bottom-up perceptual priming, or a combination of both. Such future exploration could offer valuable insights into the influence of past learning and experiences on perception.

Our research reveals that episodic memory exerts a substantial influence on the encoding and perception of new information within an extremely brief window of time. It both underscores the theoretical value of understanding episodic memory's influence on perception and opens intriguing new directions for future research. Such future explorations, fortified by the results of this study, can ultimately help unlock a more comprehensive understanding of how our past experiences shape our current and future perceptions.

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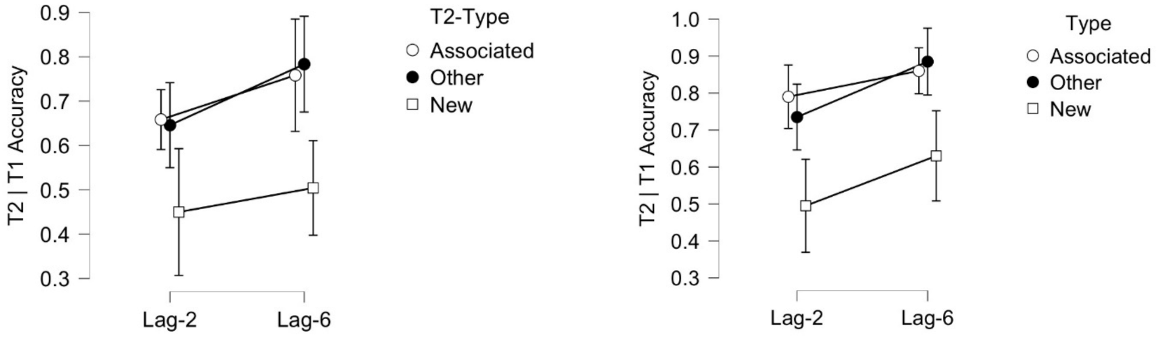
Appendix A

Pilot Study

The first pilot was run on the Prolific platform with a sample of 16 participants. A total of 4 participants were excluded due to T2 accuracy being extremely low, close to or below chance level (i.e., 11–25%). A rm-ANOVA analysis was carried out on the remaining data (n = 12). No interaction could be found between Lag and T2-Type conditions, F(2,22) = 1.1, p= .352, np2 = .09. While the effect of T2-Type reached threshold for significance, F(2,22) = 24.71, p<.001, np2 = .69, no significant effect of Lag was found, F(1,11) = 1.76, p=.21, np2=.14. Further examination of the results revealed no significant AB effect for neither of the T2 conditions (Figure A1). Performance patterns for each individual participant showed that close to half of the 14 participants had a decrease in performance when moving from a shorter to a longer lag, which falls at odds with the notion that attention would recover when there is sufficient temporal separation between targets.

Figure A1

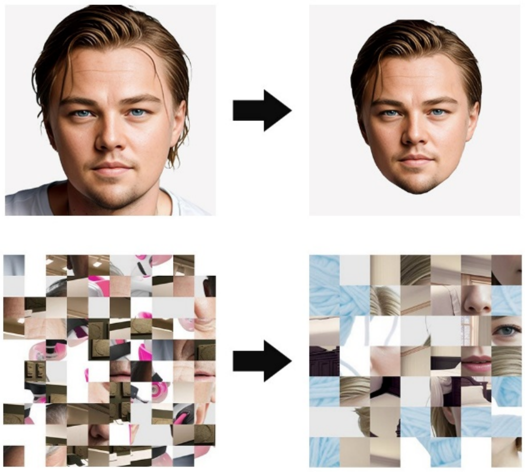
Line Plot of T2 Accuracy (Proportion T2 Correct Given Correct T1) by Lag and T2-Type. The Left Graph Shows Results After the First Pilot, the Right Graph Shows Results After the Second Pilot.



Based on these preliminary results, as well as the high number of cases that reached exclusion due to extremely low performance, we concluded that the employed experimental design was not successful in eliciting the manipulations of our key variables. Following informal interviews with volunteers taking part in the study, while addressing potential issues that could have undermined the efficacy of the experimental manipulation, more consistent results were achieved. Changes to the experiment included: (i) fine-tuning of experimental stimuli; (ii) clarity improvements in the experimental instructions; (iii) longer stimulus presentation. For the face stimuli, unnecessary details (e.g., hairstyle) were eliminated by cutting these into ovoid shapes (Figure A2). The solution helped in making these stimuli pop out less in the RSVP stream. More empty space was further added around faces and object stimuli, effectively reducing their size and making them stand out less. Both of these changes aided in increasing the difficulty of the T1 detection task, possibly increasing the chances that an AB effect would take place. Additionally, the grid size of the scrambled distractors was changed from 10x10 to 7x7 to make stimulus feature more visible (e.g., eye elements), thereby increasing the level of conceptual masking elicited by the distractors. For the instructions, an emphasis was placed on the importance of looking for the second targets at all times, even when this took longer to appear. This change aimed to address the observation that almost half of the participants had an advantage for seeing T2 at shorter as opposed to a longer lag, which suggested that they may have stopped looking for the T2 when this did not appear fast enough. As a final modification, stimulus presentation was increased from 90 to 110 ms to ease the task of detecting the T2.

Figure A2

Modification of Target and Distractor Images Following the First Pilot Study. Images From the First Pilot Are on the Left and the Images After Modification Are on the Right.



A subsequent pilot study (n = 10) was conducted on Prolific to test whether changes achieved the goal of improving the quality of the experimental manipulation. Results indicated a significant effect of Lag, F(1,9) = 6.87, p=.02, np2 = .43, and T2-Type, F(2,18) = 17.36, p<.001, np2 = .66. No interaction effect was found between Lag and T2-Type, F(2,18)=1.3, p=.3, np2=.13, although this was likely an artefact of having insufficient power to detect such effect, given the small sample size. Given the presence of a consistent AB effect across experimental conditions, as well as the absence of anomalous patterns of results (e.g., better performance at longer lag), we concluded that the changes were successful in eliciting the desired experimental manipulation.

Appendix B

AI Parameters

Face Image Generation

- **Prompt:** editorial studio close-up photo portrait of a {George Clooney} wearing a white tshirt, studio lights by vogue, (ultra photorealistic:1.3), analog style,(((white background))), even diffuse ambient lighting, soft lighting
- **Negative prompt**: (((shadow))), (((shadows)))
- **Parameters:** Steps: 70, Sampler: Euler a, CFG scale: 7, Face restoration: CodeFormer, Size: 512x512, Denoising strength: 0.8, Mask blur: 4
- **Checkpoint model**: s1dlxBrew v 0.4

Object Image Generation

- **Prompt:** RAW photo, {Pillow}, editorial product photography, soft even light, (((background is white))), 8k uhd, dslr, soft lighting, high quality, Fujifilm XT3
- **Negative prompt:** shadow, shadows, 1girl, 1boy, person, man, woman, human
- **Parameters:** Steps: 25, Sampler: Euler a, CFG scale: 7, Seed: 1067079851, Size: 512x512
- **Checkpoint model:** s1dlxBrew v 0.4

Scene Image Generation

- **Prompt:** (((photo of a {supermarket}))), product photograph, 8k uhd, center composition, central subject, centered, soft lighting, high quality, film grain
- **Negative prompt:** (((close up)))
- **Parameters:** Steps: 30, Sampler: Euler a, CFG scale: 7, Seed: 3537864746, Size: 512x512

- **Checkpoint model**: QGO – PromptingReal v. 1

Images Generated

- **Faces:** George Clooney, Britney Spears, Prince William, Beyonce, Justin Timberlake, Hilary Clinton, David Cameron, Angelina Jolie, George Bush, Tony Blair, Barack Obama, David Beckham, Jennifer Lopez, Robert De Niro, Mick Jagger, Gordon Brown, Wayne Rooney, Stephen Hawking, Sean Connery, Johnny Depp, Kylie Minogue, Margaret Thatcher, Lady Gaga, Kate Middleton, Bill Gates, Tom Cruise, Madonna, Clint Eastwood, Paul Mccartney, Harrison Ford, Oprah Winfrey, John Travolta, Julia Roberts, Pamela Anderson, Meryl Streep, Angela Merkel, Dwayne Johnson, Ariana Grande, Kim Kardashian, Cardi B, Travis Scott, Post Malone, Billie Eilish, Taylor Swift, Shawn Mendes, Harry Styles, Lil Nas X, Zendaya, Kendall Jenner, Kylie Jenner, Rihanna, Jason Momoa, Chris Hemsworth, Ryan Reynolds, Gal Gadot, Chris Evans, Keanu Reeves, Sandra Oh, Issa Rae, John Boyega, Michael B. Jordan, Viola Davis, Regina King, Lupita Nyong'O, Emma Stone, Emma Watson, Kit Harington, Sophie Turner, Maisie Williams, Timothee Chalamet, Awkwafina, Constance Wu, Brie Larson, Charlize Theron, Margot Robbie, Amy Adams, Jennifer Lawrence, Leonardo DiCaprio, Brad Pitt, Robert Downey Jr., Chris Pratt, Dave Bautista, Anthony Mackie, Tom Holland
- **Objects:** Wallet, Football, Hammer, Light Bulb, Battery, Skateboard, Necklace, Violin / Guitar, Pencil Case / Suitcase, Handbag, Pram, Trophy, Spade, Bike, Calculator, Carrot / Apple, Camera, Book, Trumpet, Basket, Umbrella, Mug, Television, Cricket Bat / Bat, Magnet, Mirror, Whisk, Paintbrush, Jug, Screwdriver, Chainsaw, Sewing Machine, Sleeping Bag, Toothbrush, Dice, Binoculars, Flowers, Artwork, Novelty Socks, Board Game, Handmade Craft, Personalized Mug, Novelty

T-Shirt, Gift Card, Photo Album, Book, Comic Book, Chocolate, Tea Set, Vinyl Record, Journal, Stationery Set, Wine Glasses, Plant, Blanket, Candle, Perfume, Jewellery, Scarf, Gloves, Hat, Sunglasses, Wallet, Keychain, Phone Case, Laptop Case, Fitness Tracker, Water Bottle, Headphones, Wireless Earbuds, Smartwatch, Virtual Reality Headset, Portable Speaker, Digital Photo Frame, Home Decor Item, Selfie Stick, Action Camera, Instant Camera, Board Game, Puzzle, Sketchbook, Guitar Pick, Microphone, Drumsticks, Art Supply Kit, Cooking Utensils

- **Locations:** Train Station, Supermarket, Cinema, Restaurant, Pub, Office, Car Park, Gym, Bowling Alley, Lift, Tree House, Living Room, Hospital, Church, Swimming Pool, Cruise Ship, Coffee Shop, Zoo, Nightclub, Park, School Yard, Police Station, Beach, Stadium, Ski Lift, Kitchen, Bedroom, Basement, Patio, Airport, Motorway, River, Cornfield, Bank, Hair Salon, Casino, Library, Museum, Art Gallery, Post Office, Hotel Lobby, Shopping Mall, Convention Centre, Conference Room, Community Centre, Arcade, Music Studio, Recording Booth, Dance Studio, Yoga Studio, Art Studio, Workshop, Exhibition Centre, Auction House, Showroom, Warehouse, Toy Store, Record Store, Bookstore, Antique Shop, Gift Shop, Florist, Craft Fair, Science Lab, University Lecture Hall, Student Union, Research Facility, Escape Room, Bowling Alley, Ice Rink, Skate Park, Trampoline Park, Laser Tag Arena, Paintball Arena, Martial Arts Studio, Theatre, Concert Hall, Music Venue, Jazz Club, Comedy Club, Circus Tent, Ice Cream Shop, Candy Store, Bakery, Food Truck Festival