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Differences in the duration of the attentional blink when viewing nature vs. urban scenes

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Abstract

The current study examined how viewing nature vs. urban scenes impacts the duration of the attentional blink. Nature scenes produce a broader allocation of attention, allowing attention to spread and reduce the ability to disengage attention. Urban scenes produce a narrowed allocation of attention, allowing efficient encoding of relevant information, inhibition of irrelevant information and a speedier disengagement of attention. Participants viewed a rapid serial visual presentation (RSVP) of either nature or urban scenes. For both scene categories, an attentional blink was evident by reduced accuracy for reporting a second target that occurred two or three scenes after an accurately reported first target. However, the duration of the attentional blink was reduced for urban scenes compared with nature scenes. A peripheral target detection task confirmed a difference in the allocation of attention between scene categories. The peripheral targets were better detected for nature scenes, suggesting that participants have a broader spread of attention for nature scenes, even in an RSVP task. The shorter duration of the attentional blink for urban scenes was consistent across four experiments with small and large sets of urban and nature scenes. Therefore, urban scenes reliably reduce the attentional blink duration compared with nature scenes, and this could be attributed to a narrowed attention allocation that allows speedier disengagement of attention in an RSVP.

Keywords Attentional blink · Dual-target rapid serial visual presentation (RSVP) · Nature scenes · Urban scenes · Disengagement of attention

The attentional blink is an effect that can be used to measure the degree to which a target stimulus occupies attentional resources and the ability to reallocate attention rapidly for detecting a second target (Dux & Marois, 2009; Nieuwenstein et al., 2005; Olivers & Nieuwenhuis, 2006). The common method for testing the attentional blink is to examine the ability to detect two sequential targets in a rapid serial visual presentation (RSVP; Raymond et al., 1992). In an RSVP, participants are sequentially presented with multiple visual stimuli at a fast rate (a fraction of a second). Participants are told to identify two targets within a stream of distractor stimuli. Often, correct identification of the first target is followed by a failure to detect the second target at short lag times, where lag is measured by the amount of time or the number of intervening stimuli between the first target and the second target (between 200 and 500 ms and/or one to two intervening stimuli). Missing the second target after detecting the first target is known as the attentional blink and is due to detection of the first target and interference from intervening distractors preventing the use of attention to detect the second target for a short period (Raymond et al., 1992; Shapiro et al., 1994). The common measures of the attentional blink effect are the magnitude of the blink, duration of the blink, and Lag 1 sparing (lack of an attentional blink when the two targets immediately follow each other; Chua, 2015; MacLean & Arnell, 2012; Willems & Martens, 2016). Changes in how attention is being engaged can modulate these attentional blink measures (Chua, 2015; Nieuwenstein et al., 2005; Zivony & Lamy, 2016). Therefore, scene categories (such as nature and urban scenes) that engage different allocations of attention could lead to different attentional blink effects.

There is evidence to suggest that the scene category can influence the attentional blink magnitude and duration. Lindh et al. (2019) found that using images from the same

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subcategory in an RSVP reduced the attentional blink magnitude, and that animate objects produced a reduced attentional blink magnitude compared with inanimate objects (see also Guerrero & Calvillo, 2016). The types of scenes used in the RSVP task can also alter the duration of the attentional blink (Einhäuser et al., 2007). Specifically, RSVPs of faces led to a shorter duration of the attentional blink than RSVPs of watches. In addition, the authors found that the attentional blink magnitude and duration improved if the category of the first and second target was different (Einhäuser et al., 2007). Therefore, scene category can influence the attentional blink in both magnitude and duration, suggesting that dissimilar categories, such as nature and urban scenes could also produce differences in attentional blink magnitude and duration.

Nature and urban scenes engage attentional resources differently. For example, nature scenes can be restorative for attention (Kaplan, 1995; Valtchanov & Ellard, 2015), allowing for shorter response times in a sustained attention task (Pilotti et al., 2015) and improved directed attention (Berman et al., 2008). This restoration may be due to nature scenes requiring fewer attentional resources to process, allowing attention resources to replenish when viewing or experiencing nature (Berman et al., 2008; Kaplan, 1995; Pilotti et al., 2015; Valtchanov & Ellard, 2015). Alternatively, urban scenes require more resources to process, leading participants to make more and shorter fixations to process urban images (Valtchanov & Ellard, 2015). This discrepancy in attention resource use when viewing these scene categories is consistent across the general subcategory of nature or urban scenes (see Menzel & Reese, 2021, for review and expansion on the natural properties of nature and urban scenes), and leads participants to alter their spread of attention when viewing these scene categories (Berto et al., 2008; Valtchanov & Ellard, 2015), which could lead to differences in attention disengagement from the scene, altering the attentional blink (Chua, 2015; Nieuwenstein et al., 2005; Zivony & Lamy, 2016).

Attentional blink theories

A common thread that connects most of the theories of the attentional blink is the use of attention resources (see Dux & Marois, 2009, for a review), where there are either not enough resources for processing both targets (Chun & Potter, 1995; Dux & Harris, 2007; Raymond et al., 1992; Shapiro et al., 1994) or resources are used inefficiently (Chua, 2015; Nieuwenstein et al., 2005; Olivers & Meeter, 2008; Olivers & Nieuwenhuis, 2006; Zivony & Lamy, 2016). In the limited resource account, distractors and/or the first target occupy the resources available to participants and leave too few for the second target to be processed effectively (Chun & Potter, 1995; Dux & Harris, 2007; Raymond et al., 1992; Shapiro et al., 1994). The distractors may take up too many resources and interfere with participants' ability to process the second target in a bottleneck from first to second stage processing of stimuli (Chun & Potter, 1995; Dux & Harris, 2007). The first target may also use up resources and leave too few resources for the second target (Chun & Potter, 1995). Slightly divergent from limited capacity accounts, the overinvestment theory suggests that resources are used inefficiently (Olivers & Nieuwenhuis, 2006). In the overinvestment account of the attentional blink, too many attentional resources are invested into the targets and distractors, leading to an inability to process the second target (Olivers & Nieuwenhuis, 2006). Therefore, it is important to think about how attention is engaged to fully understand the attentional blink.

Fluctuations in the engagement of attention might help to explain the attentional blink effects. For example, the boost and bounce model of the attentional blink suggests there is no limited resource capacity. Instead, stimuli are boosted when they match the target template and bounced, or prevented from further processing, when they do not, leading to stimuli being bounced when a second target is encountered if it does not directly follow the first target (Olivers & Meeter, 2008). In addition, when the second target in an RSVP is cued, the attentional blink is attenuated (Nieuwenstein et al., 2005; Zivony & Lamy, 2016). Nieuwenstein and colleagues (2005) coined this "delayed attentional engagement" and suggested that the attentional blink arises due to an inability to quickly reengage attention in time for when the second target is presented (see also Zivony & Lamy, 2016). Effective disengagement of attention from the first target can also attenuate the attentional blink. Chua (2015) added a moving overlay to an RSVP task along with a blank screen between stimuli that acted as multiple cues of when a stimulus left the screen. These cues allowed participants to disengage attention more effectively and attenuated the attentional blink (Chua, 2015). Therefore, variations in the time it takes to reengage attention may affect the attentional blink duration and since nature and urban scenes engage attention differently, they may differentially impact the magnitude or duration of the attentional blink. Specifically, if disengagement of attention is important for differences between nature and urban scenes, it may be expected that a speedier disengagement will lead to a shorter duration of the attentional blink (Chua, 2015).

Attentional blink measures

The attentional blink is best described as second target accuracy after the first target has been correctly identified (T2|T1) over time rather than any one instance of T2|T1 accuracy (e.g., assuming T2|T1 accuracy at Lag 2 is representative of attentional blink performance; MacLean &

Arnell, 2012). Based on this distinction, the magnitude and duration of the attentional blink may be confusable, as a decrease in one can result in an increase/decrease in the other. For example, if the attentional blink magnitude is reduced, this is also confounded with a speedier recovery (shorter duration of the blink). However, it is possible to have a large attentional blink magnitude and reduced duration (MacLean & Arnell, 2012). Although the confusability of the magnitude and duration complicates the calculation of the duration of the attentional blink (Crewther et al., 2007), locating performance asymptotes following the attentional blink magnitude can provide a measure of the duration of the attentional blink that is less affected by magnitude accuracy (MacLean & Arnell, 2012). Importantly, finding when performance reaches a level equal to the level found outside of what would be expected to be within an attentional blink range (i.e., an asymptote with the longest lag), are informative of the rates of reengagement and disengagement of attention (Chua, 2015; Nieuwenstein et al., 2005; Zivony & Lamy, 2016).

Due to the temporal nature of the attentional blink (MacLean & Arnell, 2012) we will examine the duration of the attentional blink as a measure of the disengagement afforded by nature and urban scenes. Participants should be fully recovered from the attentional blink by Lag 8 (Chun & Potter, 1995; Raymond et al., 1992), allowing Lag 8 to be used as a baseline in measuring the magnitude of the blink (i.e., Lag 8 – Lag 2; see MacLean & Arnell, 2012 for a review). However, the duration of the attentional blink (i.e., how quickly participants can recover) reflects when participants have restored attentional resources. MacLean and Arnell (2012) suggest a representative measure of the duration of the blink is when performance asymptotes, indicating a return to accuracy outside of the attentional blink (see also Crewther et al., 2007). The duration of the blink can be affected by the time it takes to disengage attention from the first target (Chua, 2015) and the category of stimuli in the RSVP (Einhäuser et al., 2007). Thus, although both magnitude and duration will be measured, the duration of the attentional blink is the measure we predict will show differences in attention engagement between scene categories as it considers the temporal component of disengagement in the attentional blink (MacLean & Arnell, 2012).

Lag 1 sparing occurs when second target identification is not impaired when it follows the first target with no intervening distractors (see Dux & Marois, 2009, for a review), but it is not always observed (Marx et al., 2014; Visser et al., 1999). For example, when targets are presented in different spatial locations, Lag 1 sparing is not observed (Visser et al., 1999). Additionally, Lag 1 sparing is not found when using complex images in the attentional blink task likely due to shifts in attention related to spatial complexity of an image (Marx et al., 2014). When disengagement from the first target is facilitated, Lag 1 sparing is diminished or goes away completely (Chua, 2015), indicating that a difference in disengagement could lead to a difference in Lag 1 sparing. It is possible that the presence of Lag 1 sparing will differ between nature and urban scenes because of differences in how attention is spatially allocated in the two scene categories (Berto et al., 2008; Valtchanov & Ellard, 2015). However, since both scene categories employ spatial attention (Berto et al., 2008; Valtchanov & Ellard, 2015), it is possible neither will produce Lag 1 sparing (Crewther et al., 2007; Marx et al., 2014; Visser et al., 1999). Therefore, in addition to examining differences in attentional blink duration for urban and nature scenes, the current study will also examine the presence of Lag 1 sparing.

Attention processing for nature and urban scenes and the attentional blink

Nature and urban scenes engage attention differently. Nature scenes produce a broad allocation of attention and urban scenes produce a narrow allocation of attention (Valtchanov & Ellard, 2015). Nature scenes have previously shown consistent effects on participants' attention engagement compared with urban scenes (Berto et al., 2008; Kaplan, 1995; Menzel & Reese, 2021; Valtchanov & Ellard, 2015). Specifically, Menzel and Reese (2021) showed that low level image properties of nature and urban scene categories produce differences in attention use but that the spatial makeup of the scenes (i.e., when not phase-scrambled as in their study) is what produces the typical effects associated with each scene category (i.e., restoration in the case of nature scenes; Kaplan, 1995). Although, the underlying mechanisms of what causes a difference in attention use between scene categories is beyond the scope of this study, it is possible low-level properties such as differences in the spatial frequency of information between the scene categories is contributing to this difference (Menzel & Reese, 2021; Valtchanov & Ellard, 2015). Important for the current study is that nature and urban scene categories produce differences in attention use and this difference could lead to either scene category producing an altered attentional blink.

The engagement of attention resources can also help determine urban and nature scenes' ability to alter the attentional blink. Nature scenes produce fewer and longer fixations (i.e., produce a broad allocation of attention; Berto et al., 2008; Valtchanov & Ellard, 2015), suggesting that attention disengagement is more difficult when viewing nature scenes. A delayed disengagement may lead to an increased attentional blink duration, as participants are unable to reengage attention in time for a second target until later in the RSVP (Chua, 2015; Nieuwenstein et al., 2005; Zivony & Lamy, 2016). Alternatively, when viewing urban scenes, participants make more fixations with shorter fixation durations (i.e., produce a narrow allocation of attention; Berto et al., 2008; Valtchanov & Ellard, 2015), suggesting attention is disengaged more effectively for urban scenes. This effective disengagement with urban scenes could lead to a reduced attentional blink duration. Therefore, the difference in engagement of attention between these two scene categories may lead to a difference in the attentional blink. Importantly, a speedier disengagement predicts a faster recovery from the attentional blink (shorter duration) but this can coincide with an attenuated magnitude (Nieuwenstein et al., 2005; Zivony & Lamy, 2016). Nevertheless, with a speedier disengagement, there should be a consistently shorter duration of the attentional blink, suggesting that if urban scenes disengage attention more effectively than nature scenes, this should lead to a shorter attentional blink duration.

Alternatively, a broad attention allocation, as elicited by nature scenes, may attenuate the attentional blink magnitude or duration. For example, when a broad spread of attention was required to detect peripheral items surrounding an RSVP, the attentional blink magnitude decreased (Taatgen et al., 2009; Wierda et al., 2010). When an overlay was presented over the RSVP task, participants had an attenuated attentional blink magnitude and duration (Arend et al., 2006; Chua, 2015). When identifying larger letters compared with small letters of compound letter stimuli for both the first and second target in an attentional blink task, participants had a shorter attentional blink duration (Crewther et al., 2007). Nature scenes may also show an attenuated attentional blink magnitude or duration because nature scenes are associated with a broader spread of attention based on the pattern of eye movements while viewing the scene category (i.e., fewer and longer fixations; Berto et al., 2008; Valtchanov & Ellard, 2015).

The current study

The current study examined the attentional blink when participants viewed nature or urban scenes. Based on urban scenes producing a narrow allocation of attention (Berto et al., 2008; Valtchanov & Ellard, 2015), which may allow for more efficient disengagement of attention, urban scenes may attenuate the attentional blink duration (Chua, 2015). Conversely, nature scenes, which elicit a broad allocation of attention and are restorative (Berman et al., 2008; Berto et al., 2008; Kaplan, 1995; Pilotti et al., 2015; Valtchanov & Ellard, 2015), may produce an attenuated attentional blink magnitude or duration. Experiment 1a was designed to test the attentional blink when using a dual-target RSVP stream composed of nature or urban scenes that have previously shown differences in restorative properties and eye-movement patterns (Valtchanov & Ellard, 2015). In Experiment 1b a peripheral item detection task was used to test the allocation of attention for each scene category in an RSVP task. In Experiments 2a–c, we expanded our stimulus set to generalize the effects from Experiment 1 and manipulated the presentation of stimuli within the RSVP in an attempt to further impact the ability to disengage attention effectively.

To foreshadow our results, we consistently found a shorter attentional blink duration (i.e., performance was asymptotic at earlier lags) for urban scenes compared with nature scenes. We attribute this shorter duration for urban scenes to differences in attention engagement, with urban scenes producing a more efficient disengagement of attention. Although, we also find a decreased attentional blink magnitude in Experiment 1a and 1b, this was not replicated in Experiments 2a–c, suggesting it was due to the limited set of stimuli used in Experiment 1a and 1b. Therefore, consistent with the expectation that the difference in attention allocation between nature and urban scenes would affect the ability to disengage attention effectively, there was a reliable effect of urban versus nature scenes on the attentional blink duration.

Experiments 1a and 1b

Experiment 1a

Methods

All Experiments reported here had protocol and analyses preregistered using AsPredicted. The preregistrations are available on Open Science Framework (https://osf.io/xn2ue/?view_only=b17de642ce9944a2b800af883f53692a) along with the raw data, stimuli, and code to run each experiment.

Participants Sixty-seven participants (M_{age} = 20.39 years, *SD* = 3.07, 54 women) were recruited from undergraduate Psychology classes at Louisiana State University. All participants received course credit for participating and had normal or corrected-to-normal vision. The first 16 participants were collected in person, and due to COVID-19, the other 51 were collected online using lab.js to program the study (Henninger et al., 2019) and Open Lab (Shevchenko, 2022) to host the experiment and store participant data. Sixteen participants were excluded due to first target accuracy being below 30 percent. One participant was excluded for a technical difficulty that resulted in stimuli being presented for longer than the desired 140 ms. Eight of the excluded participants were excluded from the in-person data collection, and nine were excluded from the online data collection.

Therefore, data from 50 participants was included in the data analysis (M_{age} = 20.38 years, SD = 2.75, 39 women). The number of participants needed was determined by estimating a moderate effect size ($\eta_p^2 = 0.08$) for the interaction between scene category and lag. Based on previous research and according to G*Power 3.1 (Faul et al., 2009), 50 participants were required to achieve a power of 0.95 ($\alpha = 0.05$; Papesh & Pinto, 2019).

Stimuli Valtchanov and Ellard's (2015) stimuli of greyscale scenes from urban and nature categories (four scenes per condition, see Fig. 1) were used. We then used TinEye (https://www.tineye.com/) to reverse image search the same scenes online in color. The final set of stimuli included 16 images, with eight in greyscale and the same eight images in color (see Fig. 1). The original images were 900 × 900 pixels and were scaled to be presented as 500 × 500 pixels on the display screen. All distractor scenes were presented in greyscale, and targets were presented in color.

Procedure and design The current study was modeled after previous attentional blink studies (Chun & Potter, 1995) including studies that used scenes within the RSVP task (Marx et al., 2014; Smith et al., 2006). Pilot studies revealed that a stimulus onset asynchrony (SOA) of 140 ms and detecting targets in color among greyscale distractors was more effective than shorter SOAs, detecting greyscale targets among color distractors, or detecting rotated targets among upright distractors at producing high and equivalent first target accuracy between scene categories. The design included two independent variables, lag and scene category, which were both manipulated within subjects. Each trial included 16 images from the same category of stimuli for both the distractors and targets, meaning that in any given trial, all of the scenes were either all urban or all nature scenes. These scenes were randomly selected from the possible four scenes in each category and input into the trial sequence with the stipulation that there could not be a scene repeated consecutively and that the first and second target were not the same scene. Across all trials, each scene was used an equal number of times as both the first and second target. Therefore, each scene from both categories appeared as the first target and second target 18 times each (36 times total). The first target in the stream appeared at one of the

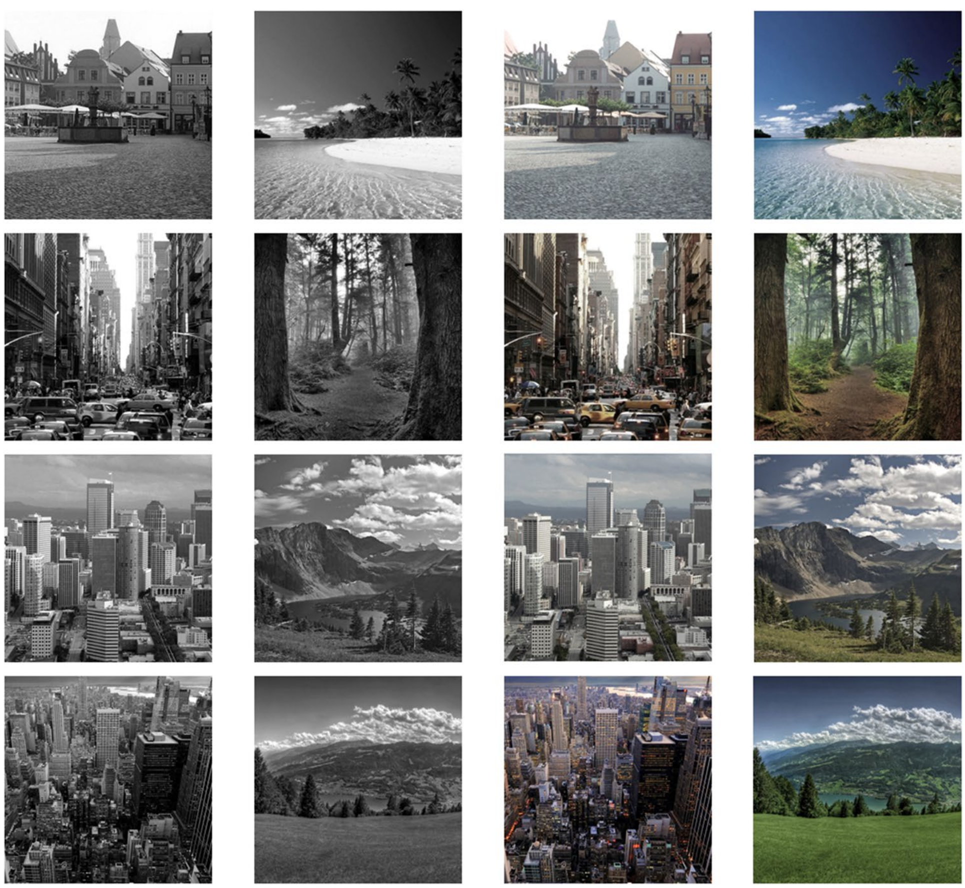

Fig. 1 Stimuli used in Experiments 1a and 1b. *Note.* From left to right, all urban scenes in greyscale, all nature scenes in greyscale, all urban scenes in color and all nature scenes in color. (Color figure online)

Serial Positions 5–7, while the second target appeared at one of the lag positions (i.e., 1–5 & 8, 140 ms–700 ms & 1,120 ms, respectively) after the first target. Participants completed 144 trials, allowing Lags 1–5 and 8 to be presented 24 times each (12 per scene condition) throughout the whole experiment. The order of scene category and lag was randomized across the 144 trials.

Participants were informed that their objective was to identify the two scenes that were in color at the end of a trial. Participants completed a practice block of 12 trials (six nature and urban scene trials each), followed by the 144 experimental trials. Before each trial there was a fixation cross presented on the center of the screen until the participant hit the spacebar to initiate the trial. Each of the 16 scenes were presented consecutively for 140ms each with no ISI between scenes (see Fig. 2). After the trial, participants were shown an array of the four scenes from the category used on that trial, and they used the mouse to identify which scenes they saw in color when prompted with "Click on the first color scene you saw, if you are not sure, take your best guess" and then the next screen presented the four scenes again and prompted, "Click on the second color scene you saw, if you are not sure, take your best guess" (see Fig. 2). After participants identified the second target, a fixation cross was presented on the screen to initiate the next trial. This continued until all 144 trials had been completed.

Results

T1 identification We analyzed T1 accuracy between urban and nature scene categories using a dependent-samples *t* test. T1 accuracy between urban (M = 74.17%, SD = 10.15%) and nature (M = 71.97%, SD = 12.16%) scene categories was not significantly different, $t(49) = 1.61$, $p = .113$, $d = 0.23$, 95% CI [−0.05, 0.51]. Therefore, the perceptual difficulty in identifying each scene category was similar.

T2|T1 accuracy We examined T2 accuracy when T1 was correctly reported (T2|T1) in a 2 (scene category: urban & nature) × 6 (lag: 1, 2, 3, 4, 5 & 8) repeated-measures ANOVA. There were significant main effects of scene category, $F(1, 49) = 25.10$, $p < .001$, $\eta_p^2 = .34$, and lag, $F(5, 245) = 59.71$, $p < .001$, $\eta_p^2 = .55$, and a significant interaction between scene category and lag, $F(5, 245) = 2.26$, $p = .049$, $\eta_p^2 = .04$ (see Fig. 3). Bonferroni-corrected pairwise comparisons were performed to follow up on the significant main effects and interaction ($\alpha = .05$, except where p values are reported as the Bonferroni corrected number of tests performed for the main effects—six for the main effect of scene category: $\alpha = .0083$, and 10 for the main effect of lag: $\alpha = .005$).

Attentional blink duration. Lag 8 accuracy is the opportunity for the fullest recovery from the attentional blink in our design and thus, we tested each lag compared with Lag 8 to

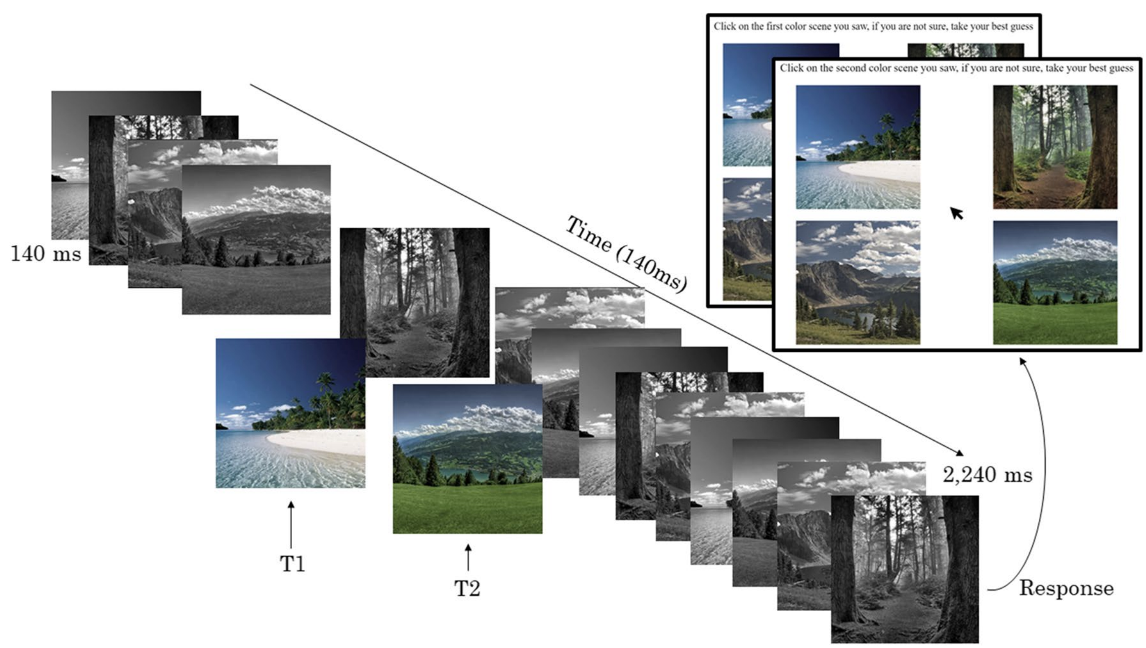

Fig. 2 Example nature trial layout. *Note*. All distractors were in greyscale and the targets were in color. Each scene was displayed for 140 ms, with no ISI, making the entire RSVP 2,240 ms. After the RSVP was complete participants were shown response screens containing the four possible scenes and they used the mouse to click on the first scene they saw in color and then a second screen appeared where they clicked on the second scene they saw in color. (Color figure online)

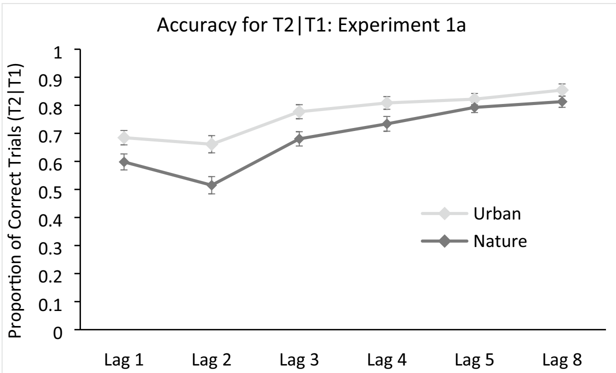

Fig. 3 Accuracy for T2|T1 in Experiment 1a. *Note*. Lag 1 accuracy is corrected for order swaps but is still not spared from the attentional blink. Error bars represent standard error

indicate when participants stopped exhibiting an attentional blink. For urban scenes, Lag 8 was not significantly different from Lag 5, $t(49) = 1.57$, $p_{10} = .123$, $d = 0.22$, 95% CI [−0.06, 0.50] or Lag 4, $t(49) = 1.75$, $p_{10} = .087$, $d = 0.25$, 95% CI [−0.04, 0.53], but Lag 3 was significantly different from Lag 8, $t(49) = 5.84$, $p_{10} < .001$, $d = 0.83$, 95% CI [0.50, 1.14], indicating there was still an attentional blink at Lag 3, but not at Lag 4. For nature scenes, Lag 8 was not significantly different from Lag 5, $t(49) = 1.19$, $p_{10} = .240$, $d = 0.17$, 95% CI [−0.11, 0.45] but was significantly different from Lag 4, $t(49) = 3.36$, $p_{10} = .002$, $d = 0.48$, 95% CI [0.18, 0.77], indicating that participants were still exhibiting an attentional blink at Lag 4. Lag 3 was also significantly different from Lag 8, $t(49) = 5.84$, $p_{10} < .001$, $d = 0.83$, 95% CI [0.50, 1.14]. Taken together, these results suggest that the attentional blink for urban scenes had recovered by Lag 4, while nature scenes did not recover until Lag 5.

Attentional blink magnitude. The magnitude of the attentional blink differed between scene categories as well. For the urban scene category, Lag 2 was significantly different from Lag 8, $t(49) = 7.65$, $p_{10} < .001$, $d = 1.08$, 95% CI [0.73, 1.43]. For the nature scene category, Lag 2 was significantly different from Lag 8, $t(49) = 9.14$, $p_{10} < .001$, $d = 1.29$, 95% CI [0.91, 1.67]. However, the attentional blink magnitude (i.e., Lag 8 – Lag 2) was smaller for urban scenes ($M = 19.31\%$, $SD = 17.86\%$) than for nature scenes ($M = 29.81\%$, $SD = 23.07\%$), $t(49) = 2.77$, $p = .008$, $d = 0.39$, 95% CI [0.10, 0.68]. In addition, performance was significantly lower for nature scenes than urban scenes at Lags 2 and 3 but no other lags (see Table 1).

Lag 1 sparing. We examined accuracy for Lag 1 including times in which participants both got the correct ordering of targets and when they did not but included the correct targets, as previously Lag 1 sparing has been susceptible to order swaps (Chun & Potter, 1995; Dux & Marois, 2009). We then compared this nonordered accuracy for Lag 1 to Lag 8 to get a comparison between the potential for Lag 1 sparing and when participants would have been recovered from the blink. For urban scenes we found a significant difference between Lag 1 accuracy and Lag 8 accuracy, $t(49) = 4.79$, $p_{10} < .001$, $d = 0.68$, 95% CI [0.37, 0.98]. For nature scenes we found a significant difference between Lag 1 accuracy and Lag 8 accuracy, $t(49) = 6.97$, $p_{10} < .001$, $d = 0.99$, 95% CI [0.64, 1.32]. Thus, even with Lag 1 accuracy corrected for order swaps, participants did not exhibit Lag 1 sparing for either scene category.

Table 1 T-tests between scene category accuracy for Experiment 1a

Lag	*p* value	Effect Size (*d*)	95% CI
1	$p_6 = .007$	0.40	[0.11, 0.68]
2	$p_6 < .001$	0.56	[0.26, 0.86]
3	$p_6 = .001$	0.52	[0.23, 0.82]
4	$p_6 = .013$	0.36	[0.08, 0.65]
5	$p_6 = .122$	0.22	[−0.06, 0.50]
8	$p_6 = .08$	0.26	[0.03, 0.54]

The paired-samples *t* test statistics represent the values of the *t* tests between scene categories (i.e., urban Lag 1 accuracy compared with nature Lag 1 accuracy) compared with a Bonferroni-corrected alpha ($\alpha = .0083$)

Experiment 1b

Experiment 1b tested whether attention allocation varies for urban and nature scenes at the short presentation times used in RSVP tasks, as others have found attention allocation differences when showing these scenes for much longer (Berto et al., 2008; Menzel & Reese, 2021; Valtchanov & Ellard, 2015). To test attention allocation in urban and nature scenes during an RSVP we used a similar setup to Experiment 1a and added peripheral dot detection trials. Past research has used peripheral item detection to determine whether participants were using a more narrow or broad attentional window (Guevara Pinto & Papesh, 2019). Guevara Pinto and Papesh (2019) presented peripheral items concurrent with a single target RSVP task and found that a narrowed attentional window in response to a more difficult RSVP task allowed for inhibition of distracting information, resulting in more misses of the peripheral items. Therefore, we predict poorer peripheral dot detection for urban scenes than for nature scenes due to the narrower allocation of attention when viewing urban scenes in the past (Berto et al., 2008; Valtchanov & Ellard, 2015). To keep the number of trials reasonable with the addition of peripheral cue trials we only used Lags 1, 2, 3, and 8. These lags allowed us to test for differences in the magnitude, but not in the duration of the attentional blink. However, the main goal of Experiment 1b was to test for differences in attention allocation between scene categories and the difference in duration effects between urban and nature scenes was replicated in Experiments 2a–c.

Methods

Participants We recruited 110 participants (M_{age} = 19.92 years, *SD* = 1.43, 92 women) for Experiment 1b from undergraduate Psychology classes at Louisiana State University. All participants received course credit for participating and had normal or corrected-to-normal vision. Thirty-two participants were excluded due to first target accuracy being below 30 percent, resulting in 78 participants overall (M_{age} = 19.91 years, *SD* = 1.44, 64 women). The number of participants needed was determined by using G*Power 3.1 (Faul et al., 2009) and the effect size from Experiment 1a for the interaction between scene category and lag ($\eta_p^2 = .04$), which indicated that 78 participants were required for the desired level of power of 0.95 ($\alpha = 0.05$).

Procedure and design Experiment 1b closely followed Experiment 1a with the addition of a peripheral dot detection task and the use of fewer lags. A portion of the trials had a peripheral dot either outward (near one of the four corners of the experiment window) or inward (near one of the four corners around the scene) on the screen (see Fig. 4). The peripheral item was a black dot that was 25 pixels in diameter (subtending 4.56° horizontally and 4.56° vertically off-center in the inner condition and subtending 8.16° horizontally and 8.16° vertically off-center in the outer condition). The dot could appear in any of the four corners of the screen (outer condition), or around the four corners of the scene (inner condition) and the corner was chosen randomly on each dot trial. The serial position of the peripheral item was random within the trial so long as it was not concurrent with or immediately before or after either of the targets and not concurrent with the first two and last two items in the RSVP. Peripheral items occurred equally often on trials with Lags 1, 2, 3, and 8 and on a total of 16 trials for each scene category (four trials at each lag for each scene category) randomly throughout the experiment. After reporting the

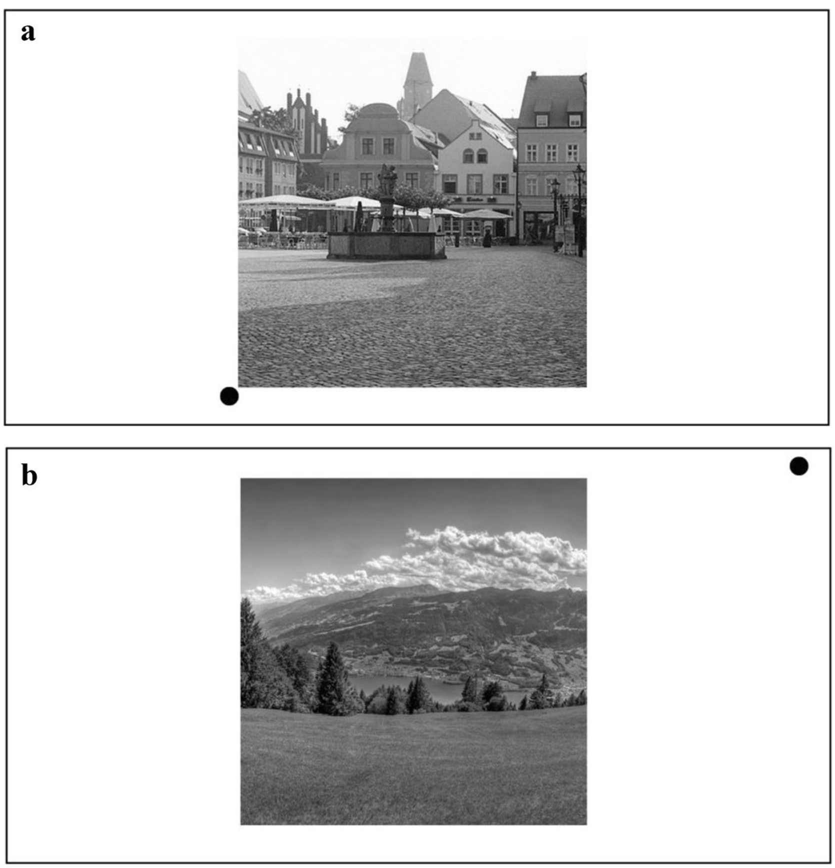

Fig. 4 Example of peripheral dot location in experiment window. *Note.* **a** represents a trial with an inner peripheral item towards the bottom left corner of a distractor scene and **b** represents a trial with an outer peripheral item towards the top right corner of the experiment window. The black border around the images represents the experiment window and how both the image and dot would be placed within it

identity of the first and second target on each trial, participants were asked "Did you see a black dot presented in this trial?" to which they would respond by clicking on "yes" indicating they saw a dot in the trial or "no" indicating they did not see a dot presented in the trial. Similar to Experiment 1a, for the no peripheral item trials, each lag had 12 trials per scene category, for a total of 96 trials for the attentional blink analysis. Thus, the total trial count was 128, with 96 trials for the attentional blink analysis and 32 trials for the peripheral item analysis.

Results

Peripheral item detection To ensure that participants were paying attention to the primary task of detecting targets in the RSVP, only peripheral item detection trials in which one of the two targets within the stream were detected were included in the analysis. This resulted in on average 49.76% of the nature scene trials and 48.96% of the urban scene peripheral item trials being usable. Additionally, when all trials were included, the outcome of the peripheral item analysis remained the same. A 2 (scene category: nature & urban) × 2 (peripheral item: inner & outer) repeated-measures ANOVA revealed no significant main effect of scene category, $F(1, 77) = 0.213$, $p = .645$, $\eta_p^2 = .003$, but a significant main effect of peripheral item, $F(1, 77) = 58.06$, $p < .001$, $\eta_p^2 = .43$. There was a significant interaction between scene category and peripheral item, $F(1, 77) = 9.51$, $p = .003$, $\eta_p^2 = .11$. Paired-samples *t* tests revealed that inner peripheral item detection for nature scenes ($M = 63.94\%$, $SD = 23.41\%$) was significantly greater than for urban scenes ($M = 58.81\%$, $SD = 22.08\%$), $t(77) = 2.05$, $p = .044$, $d = 0.23$, 95% CI [0.01, 0.46]. However, accuracy for outer item detection between nature scenes ($M = 35.58\%$, $SD = 31.67\%$) and urban scenes ($M = 39.10\%$, $SD = 32.63\%$) did not differ, $t(77) = 1.84$, $p = .07$, $d = 0.21$, 95% CI [−0.43, 0.02]. In addition, all conditions were significantly different than chance (all *p*s < .001). For the inner items, accuracy was significantly greater than chance, while for the outer items, accuracy was significantly worse than chance (see Fig. 5). Low performance was primarily due to miss trials as false alarms were rare (Nature: 2.03%, Urban: 2.10%).

T1 identification Trials with a peripheral item were excluded form T1 analysis. T1 accuracy between urban ($M = 65.60\%$, $SD = 16.00\%$) and nature ($M = 66.50\%$, $SD = 15.80\%$) scene categories was not significantly different, $t(77) = 0.633$, $p = .528$, $d = 0.07$, 95% CI [−0.15, 0.29]. Therefore, the perceptual difficulty in identifying each scene category was similar.

T2|T1 identification We examined T2 accuracy when T1 was correctly reported (T2|T1) for trials without a peripheral item in a 2 (scene category: urban & nature) × 4 (lag: 1, 2, 3 & 8) repeated-measures ANOVA. There were significant main effects of scene category, $F(1, 77) = 31.50$, $p < .001$, $\eta_p^2 = .29$, and lag, $F(3, 231) = 90.12$, $p < .001$, $\eta_p^2 = .54$, and a significant interaction between scene category and lag, $F(3, 231) = 2.94$, $p = .034$, $\eta_p^2 = .04$ (see Fig. 6). Bonferroni-corrected pairwise comparisons were performed to follow up on the significant main effects and interaction ($\alpha = .05$, except where *p* values are reported as the Bonferroni corrected number of tests performed for the main effects—four for the main effect of scene category: $\alpha = .0125$, and six for the main effect of lag: $\alpha = .0083$).

Attentional blink magnitude. There was an attentional blink for both scene categories. For the urban scene condition, Lags 2 and 3 were both significantly different from Lag 8, $t(77) = 6.36$, $p_6 < .001$, $d = 0.72$, 95% CI [0.47, 0.97], $t(77) = 3.01$, $p_6 = .003$, $d = 0.34$, 95% CI [0.11, 0.57], respectively. For the nature scene condition, Lags 2 and 3 were both significantly different from Lag 8, $t(77) = 9.85$, $p_6 <$

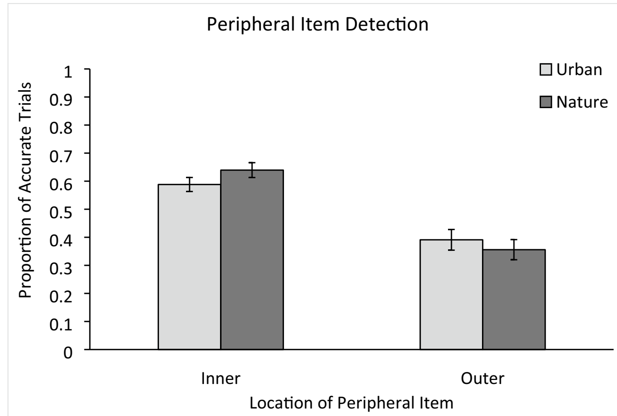

Fig 5 Accuracy for peripheral item detection in Experiment 1b. *Note.* Error bars represent standard error

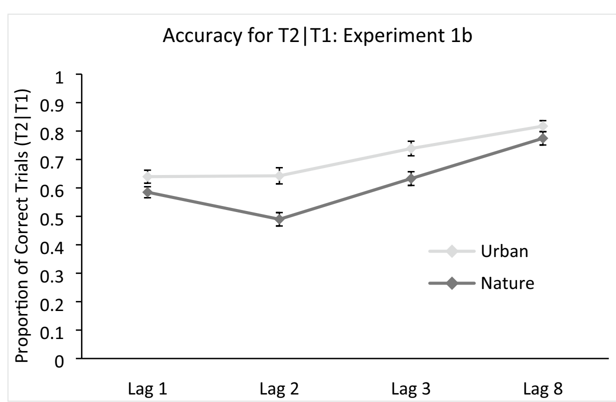

Fig. 6 Accuracy for T2|T1 in Experiment 1b. *Note.* Lag 1 accuracy is corrected for order swaps but is still not spared from the attentional blink. Error bars represent standard error

.001, $d = 1.12$, 95% CI [0.83, 1.40], $t(77) = 5.64$, $p_6 < .001$, $d = 0.64$, 95% CI [0.40, 0.88], respectively. The attentional blink magnitude (i.e., Lag 8 – Lag 2) was smaller for urban scenes (M =17.47%, SD = 24.27%) than for nature scenes (M = 28.48%, SD = 25.53%), $t(77) = 2.899$, $p = .0049$, $d = 0.33$, 95% CI [0.099, 0.56]. In addition, performance was significantly lower for nature scenes than urban scenes at Lags 2 and 3 but not Lags 1 and 8 (see Table 2).

Lag 1 sparing. As with Experiment 1a, Lag 1 accuracy included trials when participants could have made an order swap and when they correctly identified the targets in the correct order. We then took this accuracy and compared it to Lag 8 to determine the magnitude of the attentional blink for Lag 1. For urban scenes, Lag 1 accuracy was significantly different than Lag 8 accuracy, $t(77) = 7.33$, $p_6 < .001$, $d = 0.83$, 95% CI [0.57, 1.09]. For nature scenes, Lag 1 accuracy was significantly different than Lag 8 accuracy, $t(77) = 7.41$, $p_6 < .001$, $d = 0.84$, 95% CI [0.58, 1.10]. Thus, participants did not exhibit Lag 1 sparing for either scene category.

Discussion

Experiment 1a revealed a longer attentional blink duration for nature scenes than for urban scenes and a larger attentional blink magnitude for nature scenes (1a & 1b). The shorter duration and smaller magnitude of the attentional blink for urban scenes supports the hypothesis that urban scenes allow for speedier disengagement of attention. Prior research suggests that the attenuation of the attentional blink for urban scenes could be due to urban scenes eliciting a narrow attentional window (Berto et al., 2008; Valtchanov & Ellard, 2015). A narrow attentional window allows for quicker disengagement of attention, which has previously led to an attenuated attentional blink (Chua, 2015). Thus, urban scenes attenuated the attentional blink duration, supporting a difference in how attention is used in the two scene categories.

Experiment 1b provided evidence that attention is deployed differently for urban and nature scenes, even with the rapid serial presentation of the scenes. The attentional blink magnitude results of Experiment 1a were replicated, with urban scenes attenuating the attentional blink magnitude compared with nature scenes. Importantly, peripheral item detection for inner items was worse for urban scenes compared with nature scenes. Lower accuracy for inner peripheral items on urban scene trials suggests that urban scenes produce a narrower allocation of attention than nature scenes, as has been found in previous research (Berto et al., 2008; Valtchanov & Ellard, 2015). Additionally, outer peripheral item detection was poor for both scene categories, suggesting that this measure was not sensitive to differences in attentional deployment due to the outer peripheral items being too difficult to detect. Inner item accuracy being significantly above chance, suggests that this item was detectable and differences in detection between nature and urban scene trials can be attributed to a difference in attention allocation.

The difference in attention allocation between urban and nature scenes could be the reason why urban scenes help to attenuate the duration of the attentional blink compared with nature scenes. Urban scenes elicit a narrow allocation of attention (Berto et al., 2008; Valtchanov & Ellard, 2015) and a narrow allocation of attention likely allows for efficient disengagement of attention, resulting in a reduced attentional blink duration (evidenced in Experiment 1a). Taken together, these results suggest that a narrower allocation of attention could be more beneficial for reducing the attentional blink than a broader allocation of attention. However, due to the removal of Lags 4 and 5 in Experiment 1b, we were not able to test for the replication of the shortened duration of the attentional blink for urban scenes, and due to a constrained stimulus set, we cannot be certain that these effects are generalizable to other urban and nature scenes. Previous research (Menzel & Reese, 2021) suggests that nature and urban scene categories should engage attention in line with previous studies (i.e., narrow attention allocation for urban scenes; Berto et al., 2008; Valtchanov & Ellard, 2015), regardless of the nature or urban scenes used to make up these categories. Thus, to further test whether the reduced attentional blink duration is found in general for urban scenes, we performed a second experiment with an expanded stimulus set.

Table 2 Accuracy between scene categories for Experiment 1b

Lag	p value	Effect Size (d)	95% CI
1	$p_4 = 0.19$	0.27	[0.04, 0.50]
2	$p_4 < .001$	0.50	[0.27, 0.74]
3	$p_4 < .001$	0.42	[0.19, 0.65]
8	$p_4 = .025$	0.26	[0.03, 0.48]

The paired-samples t-test statistics represent the values of the t tests between scene categories (i.e., urban Lag 1 accuracy compared with nature Lag 1 accuracy) compared with a Bonferroni corrected alpha ($\alpha = .0125$)

Experiment 2a, 2b, and 2c

Experiment 2 expanded upon Experiment 1 by using a larger set of scenes that have been categorized as either urban or nature (Xiao et al., 2010). By using the stimulus sets from previous research (Valtchanov & Ellard, 2015) in Experiments 1a and 1b, the stimuli were limited (only four scenes per category). The small stimulus set could have led to grouping by category to improve performance (Guerrero

& Calvillo, 2016; Lindh et al., 2019), repetition blindness (Arnell & Shapiro, 2011), or negative and positive priming (Harris et al., 2010; Rusconi & Huber, 2018). Therefore, the results may not be entirely due to differences in attention allocation between scene categories. For this reason, in Experiments 2a–c we use a broader range of stimuli and more closely mirrored previous attentional blink designs that have included larger stimulus sets (Chun & Potter, 1995; Raymond et al., 1992). Additionally, we were interested in the differences in disengagement between urban and nature scenes and ran two experiments (2b & 2c) that aimed to manipulate participants' ability to disengage attention. Experiment 2b included a blank screen between each image to make disengagement easier (Chua, 2015). Experiment 2c varied the presentation time of each image to make disengagement harder, as spatial and temporal predictability impacts detection and identification response time (Beck et al., 2014).

The manipulations in Experiment 2b and 2c were designed to see if the effects of scene category could be impacted by other manipulations that could also impact disengagement. In Experiment 2b blank screens were inserted after every scene to provide an additional cue of when a scene had left the screen, thereby aiding disengagement. Chua (2015) used a blank screen and a moving dot overlay to aid earlier disengagement of attention. We used scenes in our study, unlike Chua (2015) and thus, expected to mirror the moving dot overlay with a change in scene representing a change in the "overlay" and the blank screen acting as another cue to disengage attention. If disengagement is made easier by the addition of blank screens, the effect of nature scenes making disengagement harder and increasing the duration of the attentional blink may be eliminated. In Experiment 2c the length of time a scene was displayed varied making it more difficult to predict when the scene would be removed and therefore when to disengage attention. If disengagement is made more difficult by manipulating stimulus presentation time, the effect of urban scenes making disengagement harder and shortening the duration of the attentional blink may be eliminated. However, if the effect of scene category on disengagement is stronger than these disengagement cues, the differences in disengagement between categories would remain. To foreshadow the results of Experiment 2, nature scenes led to a longer duration of the attentional blink than urban scenes across all three experiments. Therefore, this effect is robust and persists even when there are added cues meant to aid disengagement (2b) and when predicting the time to disengage is more difficult (2c).

Methods

Participants Participant demographic summary statistics are reported in Table 3 for each Experiment. The number of participants needed was determined using the effect size from Experiment 1a, that found an interaction between scene category and lag ($\eta_p^2 = 0.04$). Based on this effect size, G*Power 3.1 (Faul et al., 2009) suggested we needed 66 participants to achieve a power of 0.80 ($\alpha = 0.05$). All participants received course credit for participating and had normal or corrected-to-normal vision. All participants completed the task online using the lab.js program (Henninger et al., 2019) and Open Lab (Shevchenko, 2022) to host the experiment and store participant data.

Stimuli Stimuli for Experiment 2 were obtained from the SUN database (Xiao et al., 2010) that categorizes images by crowdsourcing. The subcategories used for nature scenes were "Beach," "Forest," "Mountain," "River," and the subcategories used for urban scenes were "Apartment Building," "Plaza," "Skyscraper," and "Street." These subcategories were used to obtain 24 images as the distractor images and 8 images as the target images for each category and were divided evenly among the subcategories to closely match typical attentional blink studies that use letters and digits as distractors and targets (Chun & Potter, 1995; Raymond et al., 1992; see Dux & Marois, 2009; Willems & Martens, 2016, for a review; see Fig. 7). By using images from the SUN database (Xiao et al., 2010), we can be more certain that the images used represent those that belong to the broad category of nature or urban. Relying on scenes that fit in the broad category of nature or urban should produce similar

Table 3 Participants recruited for Experiments 2a–c

	Before Exclusion	Age (*M*)	*SD*	Women	After Exclusion	Age (*M*)	*SD*	Women
Experiment 2a	71	19.62	2.72	59	66	19.62	2.79	54
Experiment 2b	70	19.46	1.64	64	66	19.5	1.67	60
Experiment 2c	90	19.83	4.399	71	66	20.05	5.07	50

Experiment 2c included one individual who identified as transgender and one individual who preferred not to provide a gender identity. There were 25 participants excluded across all three experiments (3 from 2a, 4 from 2b, and 18 from 2c) for overall first target accuracy being below 30%. All other participants were excluded for being collected after the required number of participants was achieved

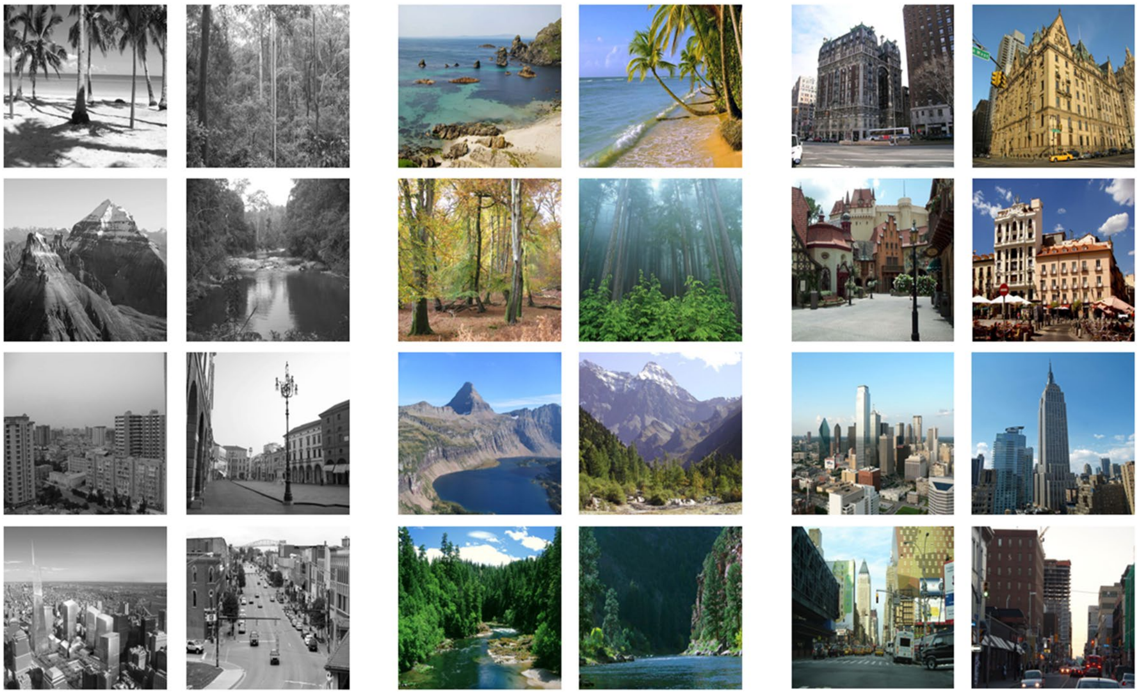

Fig. 7 Stimuli used in Experiments 2a–c. *Note.* Stimuli taken from the SUN Database (Xiao et al., 2010). The left eight are examples of distractors from the four subcategories per scene category (the top four are nature scenes and the bottom four are urban scenes). The middle stimuli depict the eight target images for the nature scene category. The right stimuli depict the eight target images for the urban scene category. (Color figure online)

attention engagement to previous studies (Berto et al., 2008; Valtchanov & Ellard, 2015) based on previous work showing consistent effects within nature or urban scene categories (Menzel & Reese, 2021).

Procedure and design Experiment 2a was modeled after Experiment 1a, except where otherwise stated. Each trial included 18 images with the distractor scenes being randomly selected from the 24 possible distractors without replacement. The targets were chosen randomly from the eight possible targets, such that the two targets were not from the same subcategory (i.e., a beach scene would not be both the first and second target on any given trial). To randomize the target scene category evenly, we used the subcategory for randomization to ensure every subcategory was represented equally. Therefore, each scene subcategory appeared with every other scene subcategory at each lag (i.e., the beach subcategory appeared as the first target three times at each lag with the different subcategories composing the second target). Setting the RSVP up this way allowed each scene to be used nine times as both the first and second target throughout the experiment. The first target in the stream appeared at one of the Serial Positions 5–7, while the second target appeared at one of the lag positions (1–5 & 8, 140 ms–700 ms & 1,120 ms, respectively; see Fig. 8) after the first target. Participants completed 144 trials, allowing Lags 1–5 and 8 to be presented 24 times each (12 per scene condition) throughout the entire experiment. The order of scene category and lag was randomized across the 144 trials.

Experiment 2b and 2c closely mirrored Experiment 2a. In Experiment 2b, stimuli were presented for 100 ms with a 40-ms blank screen inserted after every scene. Therefore, the timing between Experiment 2a and 2b was the same, where each trial would last 2,520 ms. Experiment 2c manipulated the presentation time of the scenes, randomly assigning them a value from 100 to 140 ms in intervals of 5 ms (i.e., one scene could be presented for 105 ms and the next could be presented for 140 ms). Each presentation time was used twice each trial, meaning two scenes would be presented for 105 ms in the stream. The presentation time of each stimulus was randomly assigned with the stipulation that a presentation time did not repeat consecutively (e.g., two scenes would not be presented back-to-back at 105ms). Therefore, Experiment 2c trials lasted 2,160 ms each.

Results

T1 identification To test for differences in T1 accuracy, we ran a mixed ANOVA between scene category (nature vs. urban) and experiments (control vs. blank screen vs timing). This analysis indicates no difference in difficulty across

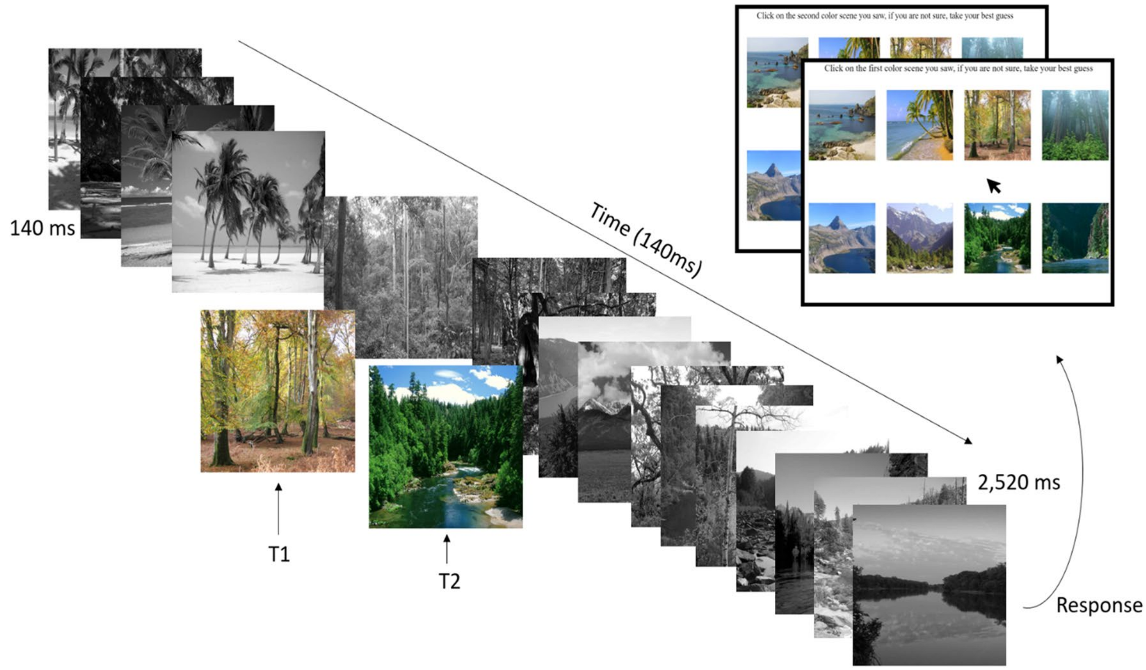

Fig. 8 Trial layout for Experiments 2a–c from nature category. *Note.* All distractors were in greyscale, and the targets were in color. Each scene was displayed for 140 ms, with no ISI, making the entire RSVP 2,520 ms. After the RSVP was complete, participants were shown response screens containing eight images and they used the mouse to click on the first and second scenes they saw in color. Experiment 2b inserted blank screens between every scene, with the scene being presented for 100ms and the blank screen being presented for 40 ms. Experiment 2c had each scene randomly presented for a period between 100 and 140ms in intervals of 5 ms, with the stipulation that timings would not repeat consecutively. (Color figure online)

experiments outside of the attentional blink (i.e., T2|T1). There was no main effect of scene category, $F(1, 195) = 2.19$, $p = .141$, $\eta_p^2 = .01$, indicating that T1 accuracy did not differ between scene categories, further demonstrating the perceptual difficulty in identifying each scene category was similar. There was no main effect of experiment, $F(2, 195) = 2.74$, $p = .07$, $\eta_p^2 = .03$, nor a significant interaction, $F(2, 195) = 1.12$, $p = .329$, $\eta_p^2 = .01$. Thus, the scene categories were equally identifiable in all three experiments and varied usefulness of disengagement cues did not affect overall ability to detect the first target (see Table 4).

T2|T1 accuracy between experiments We examined T2|T1 accuracy in a 2 (scene category: urban & nature) × 6 (lag: 1, 2, 3, 4, 5, & 8) × 3 (experiment: control, blank screen, & timing) mixed ANOVA to see if there was an effect of experiment that would lead to varied T2|T1 accuracy across tasks. There were significant main effects of scene category, $F(1, 195) = 13.62$, $p < .001$, $\eta_p^2 = .07$, lag, $F(5, 975) = 391.68$, $p < .001$, $\eta_p^2 = .67$, and experiment, $F(2, 195) = 7.36$, $p < .001$, $\eta_p^2 = .07$. There was an interaction between scene category and lag, $F(5, 975) = 11.03$, $p < .001$, $\eta_p^2 = .05$. There were no other significant interactions, all *ps* > .05. The main effect of experiment was due to significantly poorer accuracy in Experiment 2b ($M = 51.79$, $SD = 11.91$) compared with Experiment 2a ($M = 57.67$, $SD = 12.42$), $t(130) = 2.78$, $p = .006$, $d = 0.48$, 95% CI [0.13, 0.83] and Experiment 2c ($M = 50.60$, $SD = 12.54$) compared with Experiment 2a, $t(130) = 3.25$, $p = .001$, $d = 0.57$, 95% CI [0.21, 0.92], as there was no difference between Experiments 2b and 2c, $t(130) = 0.56$, $p = .578$, $d = 0.097$, 95% CI [−0.44, 0.24]. Due to the lack of interactions with our experiment variable, the remaining analyses are conducted for each experiment separately (Fig. 9).

Table 4 Descriptive statistics for T1 accuracy for Experiments 2a–c

Experiment	Urban		Nature	
	M	*SD*	*M*	*SD*
2a	67.51	16.04	67.07	15.28
2b	62.54	15.13	64.6	14.12
2c	60.5	17.63	62.12	15.57

We examined T2 accuracy when T1 was correctly reported (T2|T1) in a 2 (scene category: urban & nature) × 6 (lag: 1, 2, 3, 4, 5 & 8) repeated-measures ANOVA for each Experiment. For Experiment 2a, there were significant main effects of scene category, $F(1, 65) = 5.88$,

Table 5 Paired comparisons between lags across scene categories for Experiment 2a

	Lag Comparisons	Nature				Urban			
		$t(65)$	p_{10}	d	95% CI	$t(65)$	p_{10}	d	95% CI
Attentional Blink Duration	Lag 8 * 5	3.22	= .002	0.396	[0.14, 0.65]	0.76	= .451	0.09	[-0.15, 0.33]
	Lag 8 * 4	5.25	< .001	0.65	[0.38, 0.91]	0.63	= .531	0.08	[-0.16, 0.32]
	Lag 8 * 3	9.13	< .001	1.12	[0.81, 1.43]	5.06	< .001	0.62	[0.36, 0.88]
	Lag 8 * 2	12.50	< .001	1.54	[1.18, 1.89]	10.30	< .001	1.27	[0.94, 1.59]
Lag 1 sparing	Lag 8 * 1	16.63	< .001	2.05	[1.62, 2.47]	8.65	< .001	1.07	[0.76, 1.37]

The paired-samples *t* test statistics represent the values of the *t* tests between lag conditions (i.e., urban Lag 1 accuracy compared with urban Lag 8 accuracy) compared with a Bonferroni corrected alpha (α = .005)

p = .018, η_p^2 =.08, and lag, $F(5, 325) = 126.06$, $p < .001$, η_p^2 =.66, and a significant interaction between scene category and lag, $F(5, 325) = 4.62$, $p < .001$, η_p^2 =.07. For Experiment 2b, there was no significant main effect of scene category, $F(1, 65) = 2.65$, $p = .109$, η_p^2 =.04, but we did observe a significant main effect of lag, $F(5, 325) = 162.50$, $p < .001$, η_p^2 =.71. We also observed a significant interaction between scene category and lag, $F(5, 325) = 2.61$, $p = .024$, η_p^2 =.04. For Experiment 2c, there were significant main effects of scene category, $F(1, 65) = 5.46$, $p = .022$, η_p^2 =.08, and lag, $F(5, 325) = 109.15$, $p < .001$, η_p^2 =.63. We also observed a significant interaction between scene category and lag, $F(5, 325) = 4.74$, $p < .001$, η_p^2 =.07. Bonferroni-corrected pairwise comparisons were performed to follow up on the significant main effects and interactions (α = .05, except where p values are reported as the Bonferroni corrected number of tests performed for the main effects—six for the main effect of scene category: α = .0083, and 10 for the main effect of lag: α = .005 for each Experiment).

Experiment 2a. There was an attentional blink for both scene categories, evidenced by significantly poorer performance at Lags 2 and 3 compared with 8 (see Table 5). To measure the duration of the attentional blink, as with Experiment 1a, we compared each lag to Lag 8 (the furthest point out for recovery in our design) to indicate at which lag each scene category stopped exhibiting an attentional blink, indicating the duration of the attentional blink. For urban scenes, Lag 8 was not significantly different from Lag 5 or Lag 4 but was significantly different from Lag 3 (see Table 5; Fig. 9). For nature scenes, Lag 8 was significantly different from Lag 5, Lag 4, and Lag 3. This indicates that urban scenes fully recovered from the attentional blink by Lag 4, while nature scenes were still recovering at Lag 5 and based on no asymptote, may still have been recovering until Lag 8 or beyond. However, without more lags we are not able to see this behavior (i.e., Lags 6 and 7, as well as lags further out than Lag 8 to see if recovery would continue for nature scenes).

The attentional blink magnitude (i.e., Lag 8 – Lag 2) for urban scenes (M = 35.73%, SD = 18.88%) did not differ compared with nature scenes (M = 37.41%, SD = 21.09%), $t(65) = 0.56$, $p = .579$, $d = 0.07$, 95% CI [−0.31, 0.17]. Lastly, there was no Lag 1 sparing in Experiment 2a, as Lag 1 significantly differed compared with Lag 8 even when corrected for order swaps (see Table 5). Accuracy between scene categories did not differ at any lags except Lag 8 (see Table 6; Fig. 9).

Experiment 2b. There was an attentional blink for both scene categories, evidenced by significantly poorer performance at Lags 2 and 3 compared with 8 (see Table 7). As for the duration of the attentional blink for urban scenes, Lag 8 was not significantly different from Lag 5 or Lag 4 but was significantly different from Lag 3 (see Table 7; Fig. 10). For nature scenes, Lag 8 was significantly different from Lag 5, Lag 4, and Lag 3. This further indicates that urban scenes fully recovered from the attentional blink by Lag 4, while nature scenes were still recovering at Lag 5 and could have still been recovering past Lag 8, as there was no asymptotic behavior.

The attentional blink magnitude (i.e., Lag 8 – Lag 2) for urban scenes (M = 39.38%, SD = 19.96%) did not differ

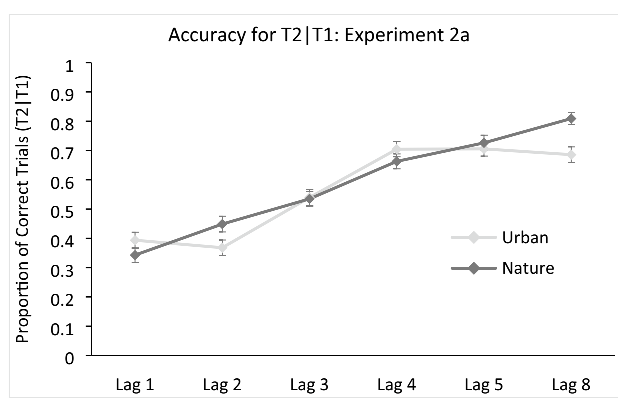

Fig. 9 Accuracy for T2|T1 in Experiment 2a. *Note.* Lag 1 accuracy is corrected for order swaps but is still not spared from the attentional blink. Error bars represent standard error

Table 6 Paired comparisons between scene categories at each lag

Lag	Experiment 2a			Experiment 2b			Experiment 2c		
	p_6	Effect Size (*d*)	95% CI	p_6	Effect Size (*d*)	95% CI	p_6	Effect Size (*d*)	95% CI
1	.754	0.04	[−0.28, 0.20]	.6597	0.05	[−0.296, 0.19]	.027	0.28	[0.31, 0.52]
2	.009	0.33	[0.08, 0.57]	.018	0.30	[0.05, 0.55]	.005	0.36	[0.11, 0.60]
3	.873	0.02	[−0.22, 0.26]	.9499	0.01	[−0.25, 0.23]	.337	0.12	[−0.12, 0.36]
4	.137	0.19	[−0.06, 0.43]	.128	0.19	[−0.05, 0.43]	.124	0.19	[−0.05, 0.43]
5	.482	0.09	[−0.33, 0.16]	.961	0.01	[−0.25, 0.24]	.161	0.17	[−0.42, 0.07]
8	<.001	0.58	[0.31, 0.84]	<.001	0.43	[0.18, 0.68]	<.001	0.46	[0.21, 0.71]

The paired-samples *t* test statistics represent the values of the *t* tests between scene categories (i.e., urban Lag 1 accuracy compared with nature Lag 1 accuracy) compared with a Bonferroni corrected alpha (α = .0083)

compared with nature scenes (M = 41.58%, SD = 19.30%), t(65) = 0.64, p = .522, d = 0.08, 95% CI [−0.32, 0.16]. Lastly, there was no Lag 1 sparing in Experiment 2b, as Lag 1 significantly differed compared with Lag 8 even when corrected for order swaps (see Table 7). Accuracy between scene categories did not differ at any lags except Lag 8 (see Table 6; Fig. 10).

Experiment 2c. There was an attentional blink for both scene categories, evidenced by significantly poorer performance at Lags 2 and 3 compared with 8 (see Table 8). As for the duration of the attentional blink for urban scenes, Lag 8 was not significantly different from Lag 5 or Lag 4 but was significantly different from Lag 3 (see Table 8; Fig. 11). For nature scenes, Lag 8 was not significantly different from Lag 5 but was significantly different from Lag 4 and Lag 3. This further indicates that urban scenes fully recovered from the attentional blink by Lag 4, while nature scenes were still recovering until Lag 5, which was not significantly different from Lag 8, indicating there may be asymptotic behavior starting at Lag 5 for nature scenes.

The attentional blink magnitude (i.e., Lag 8 – Lag 2) for urban scenes (M = 35.95%, SD = 21.89%) did not differ compared with nature scenes (M = 37.85%, SD = 21.29%), t(65) = 0.54, p = .592, d = 0.07, 95% CI [−0.31, 0.18]. Lastly, there was no Lag 1 sparing in Experiment 2c, as Lag 1 significantly differed compared with Lag 8 even when corrected for order swaps (see Table 8). Accuracy between scene categories did not differ at any lags except Lags 2 and 8 (see Table 6; Fig. 11).

Discussion

Consistent with Experiment 1a, all three experiments (2a–c) showed an attentional blink for both scene categories and a shorter attentional blink duration for urban scenes. The shorter duration was consistent even when the RSVP was manipulated to make disengagement less (2b) or more (2c) challenging. Although, the magnitude difference between nature and urban scenes from Experiment 1a and 1b did not replicate, the difference in the duration for urban scenes compared with nature scenes was reliable. Urban scenes recovered faster than nature scenes, evidenced by asymptotic behavior (accuracy flattening toward expected levels outside of the attentional blink) starting at Lag 4 onward, compared with nature scenes. This asymptotic behavior has previously been used to measure differences in attentional blink durations (MacLean & Arnell, 2012). The RSVP manipulations in Experiments 2b and 2c were predicted to make disengagement easier and harder, respectively, however, both manipulations instead decreased T2|T1 accuracy. Even with decreased T2|T1 accuracy, urban scenes produced a

Table 7 Paired comparisons between lags across scene categories for Experiment 2b

	Lag Comparisons	Nature				Urban			
		t(65)	p_{10}	d	95% CI	t(65)	p_{10}	d	95% CI
Attentional Blink Duration	Lag 8 × 5	3.12	= .0027	0.38	[0.13, 0.63]	0.12	= .902	0.02	[−0.26, 0.23]
	Lag 8 × 4	6.58	<.001	0.81	[0.53, 1.09]	2.29	= .025	0.28	[0.04, 0.53]
	Lag 8 × 3	9.69	<.001	1.19	[0.87, 1.51]	7.36	<.001	0.91	[0.62, 1.19]
	Lag 8 × 2	13.77	<.001	1.695	[1.31, 2.07]	15.08	<.001	1.86	[1.45, 2.25]
Lag 1 sparing	Lag 8 × 1	13.12	<.001	1.62	[1.25, 1.98]	9.61	<.001	1.18	[0.87, 1.496]

The paired-samples *t* test statistics represent the values of the *t* tests between lag conditions (i.e., urban Lag 1 accuracy compared with urban Lag 8 accuracy) compared with a Bonferroni corrected alpha (α = .005)

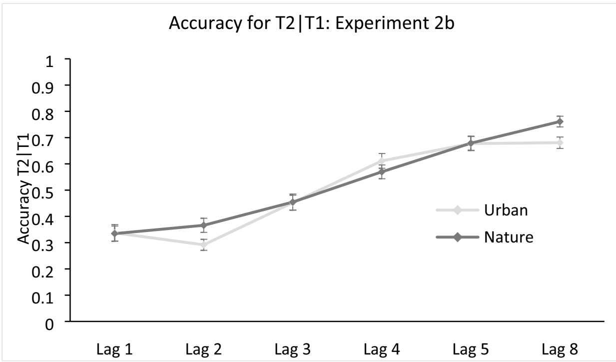

Fig. 10 Accuracy for T2|T1 in Experiment 2b. *Note*. Lag 1 accuracy is corrected for order swaps but is still not spared from the attentional blink. Error bars represent standard error

shorter duration of the attentional blink with an asymptote in urban scene T2|T1 accuracy by Lag 4, with no asymptote evidenced for nature scenes. Thus, we found a reliable effect of an extended duration of the attentional blink for nature scenes with a larger stimulus set. This effect could be due to the broader allocation of attention delaying disengagement for nature scenes and the narrowed attention allocation for urban scenes allowing for faster disengagement of attention.

Although there is clear evidence of an earlier asymptote for urban scenes, it is unclear if an asymptote was obtained for nature scenes. Therefore, we may be underestimating the actual size of the attentional blink for nature scenes (MacLean & Arnell, 2012). Lag 8 accuracy was higher for nature scenes than urban scenes in Experiments 2a–c. Based on previous research, Lag 8 indicates T2|T1 accuracy when participants are completely recovered from the attentional blink (Chun & Potter, 1995; Raymond et al., 1992). Therefore, by looking at Lag 8 T2|T1 accuracy, it can be assumed that participants should be outside of the attentional blink range. Although Lag 8 T2|T1 accuracy is higher for nature scenes than urban scenes, there was no difference in T1 accuracy between urban and nature scenes. Thus, the differences in T2|T1 accuracy at Lag 8 are not attributable to the identification of features in the scenes needed for identifying the scene. Instead, previous research has indicated that the duration of the attentional blink can be extended out past the range of where Lag 8 falls in our study (1,120 ms; see Crewther et al., 2007; MacLean & Arnell, 2012). Therefore, nature scenes may still be recovering from the attentional blink until Lag 8 and beyond while urban scenes have recovered by Lag 4 consistently. Accordingly, any differences in Lag 8 T2|T1 accuracy in Experiments 2a–c may be attributable to an underestimation of the attentional blink for nature scenes due to not having intervening lags between Lags 5 and 8 in our study and may even require lags further out than Lag 8 to fully capture the effect (Crewther et al., 2007; MacLean & Arnell, 2012).

The manipulations in Experiments 2b & 2c were intended to facilitate or impair disengagement respectively. Although both manipulations decreased T2|T1 performance compared with Experiment 2a, they also both replicated the attenuated attentional blink duration for urban scenes compared with nature scenes. In Experiment 2b, blank screens inserted after every scene was modeled after Chua (2015), which included multiple indicators of when to disengage attention. In Chua (2015), a moving dot overlay along with blank screens after every stimulus gave multiple indicators of when a stimulus left the screen and participants should disengage attention. In our case, each scene and subsequent blank screen were followed by a different scene, and thus should have acted similarly to the moving dots based on a large change in information on the display between scenes. Rather than making disengagement easier as was found in Chua (2015) the blank screens after every stimulus made disengagement more difficult, evidenced by worse T2|T1 accuracy and brought the design in line with previous attentional blink studies (Papesh & Pinto, 2019; Raymond et al., 1992). In Experiment 2c, the manipulation of the stimuli presentation time was, to our knowledge, the first of its kind. In our case, it appears to have made disengagement more difficult overall due to overall lower T2|T1 accuracy. Nevertheless, even with a decrease in T2|T1 accuracy, we provided further support that urban scenes produce a speedier

Table 8 Paired comparisons between lags across scene categories for Experiment 2c

	Lag Comparisons	Nature				Urban			
		$t(65)$	p_{10}	d	95% CI	$t(65)$	p_{10}	d	95% CI
Attentional Blink Duration	Lag 8 × 5	2.09	= .040	0.26	[0.01, 0.50]	0.54	= .569	0.07	[−0.17, 0.31]
	Lag 8 × 4	8.09	<.001	0.996	[0.698, 1.29]	1.20	= .235	0.15	[−0.39, 0.096]
	Lag 8 × 3	8.71	<.001	1.07	[0.77, 1.37]	3.43	= .001	0.42	[0.17, 0.67]
	Lag 8 × 2	13.33	<.001	1.64	[1.27, 2.01]	10.99	<.001	1.35	[1.01, 1.68]
Lag 1 sparing	Lag 8 × 1	12.76	<.001	1.57	[1.21, 1.93]	7.22	<.001	0.89	[0.60, 1.17]

The paired-samples *t* test statistics represent the values of the *t* tests between lag conditions (i.e., urban Lag 1 accuracy compared with urban Lag 8 accuracy) compared with a Bonferroni corrected alpha (α = .005)

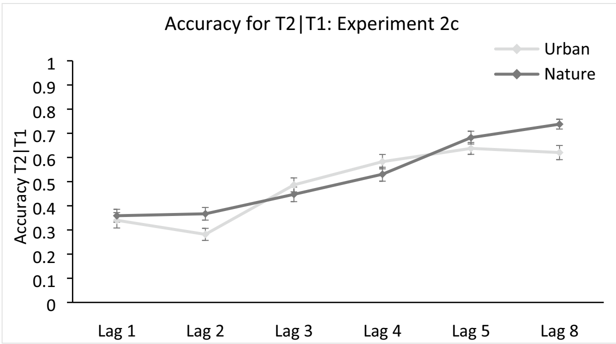

Fig. 11 Accuracy for T2|T1 in Experiment 2c. *Note.* Lag 1 accuracy is corrected for order swaps but is still not spared from the attentional blink. Error bars represent standard error

disengagement, leading to a reduced duration of the attentional blink.

In Experiments 2a–c, there was no difference in the magnitude of the attentional blink between nature and urban scenes. Therefore, the difference in magnitude in Experiments 1a and 1b is likely due to the small stimulus set causing grouping by category (Guerrero & Calvillo, 2016; Lindh et al., 2019), repetition blindness (Arnell & Shapiro, 2011), or negative and positive priming (Harris et al., 2010; Rusconi & Huber, 2018). The motivation for using a larger stimulus set was to be more generalizable and to avoid these potential problems with a small stimulus set. Thus, the difference in the duration of the attentional blink, but not the magnitude, was consistent and generalized to a larger stimulus set. Additionally, this effect was replicated across three experiments (2a–c) where the overall T2|T1 accuracy was modulated, but still led to urban scenes producing a shorter duration of the attentional blink. We attribute this shorter duration of the attentional blink to urban scenes narrowing of attention (evidenced in Experiment 1b) leading to a speedier disengagement of attention.

General discussion

This study extends previous research on both the attentional blink and attention allocation in nature and urban scenes. Importantly, through four experiments we have shown that urban scenes produce a shorter duration of the attentional blink. This effect was reliable across different stimulus sets and different overall T2|T1 difficulty. Previous research and the dot probe task of Experiment 1b suggest that this effect could be due to urban scenes producing a narrower allocation of attention compared with nature scenes, leading to a speedier disengagement of attention. Therefore, the attentional blink recovers faster for urban scenes, and this is likely due to urban scenes producing a narrower attention allocation, leading to a speedier disengagement of attention (Chua, 2015; Nieuwenstein et al., 2005; Zivony & Lamy, 2016).

Attentional blink with urban and nature scenes

Previous research has identified a sensitive period for the attentional blink within a 200–500-ms time frame after a first target is identified (Raymond et al., 1992). Based on our design, this 200–500-ms time frame falls on Lags 2 and 3, with Lag 8 being well outside the attentional blink window in most cases. Therefore, the difference in performance between Lag 2 and Lag 8 indicates the magnitude of the attentional blink, and by examining which lags do not differ outside of this attentional blink window (i.e., exhibit flat or asymptotic behavior), we can examine the duration of the attentional blink. All five experiments provide evidence that urban and nature scenes engage attention differently. The attentional blink was consistently shorter for urban than for nature scenes, suggesting that nature scenes, while restorative in some settings (Berman et al., 2008; Berto et al., 2008; Kaplan, 1995; Pilotti et al., 2015; Valtchanov & Ellard, 2015), are less beneficial for rapid detection of multiple targets. In Experiment 1b, we provided evidence that rapid serial presentation can lead to a broader spread of attention for nature scenes than for urban scenes. The current results suggest that urban scenes (as a category; Menzel & Reese, 2021) lead to a narrow allocation of attention, and this difference in how attention is allocated could play a role in the shorter duration of the attentional blink for urban scenes.

Our results support and extend other studies that have found a difference in attentional blink measures between scene categories (Einhäuser et al., 2007; Guerrero & Calvillo, 2016; Lindh et al., 2019). Where these other studies found differences between animate and inanimate categories (Einhäuser et al., 2007; Guerrero & Calvillo, 2016; Lindh et al., 2019), we found differences between natural scene categories, with nature and urban scenes producing different attention allocations. Previous studies have attributed differences in the attentional blink between categories to differences in conscious access to the categories, often related to the animacy of the category. We add to this literature by showing a difference in the duration of the attentional blink between urban and nature scene categories and attributing this difference to how attention is allocated in these different scene categories. Urban and nature scene categories have previously been shown to engage attention differently based on their category rather than any one scene within that category (Berto et al., 2008; Menzel & Reese, 2021; Valtchanov & Ellard, 2015). Therefore, urban scenes in general are likely to attenuate the attentional blink compared with nature scenes in general. More specifically, with a narrow allocation of attention from viewing urban scenes, it is easier to disengage attention and shorten the duration of the attentional blink compared with a broad allocation of attention, as elicited by nature scenes.

Moving from Experiment 1 to Experiment 2, we broadened the stimulus set used to generalize the effects found in Experiment 1 and to confirm any set of scenes from either a nature or urban scene category would produce consistent results for the attentional blink. In Experiment 1 the scenes used had previously shown differences in attention allocation (Valtchanov & Ellard, 2015). However, by using a small stimulus set, this likely led to a confound that produced a difference in the magnitude between scene categories (urban scenes had a smaller attentional blink magnitude than nature scenes). In addition, the perceptual distance between scene categories was not controlled for, meaning scenes may have been more hetero- or homogeneous within either broad scene category (nature or urban). While this may be a confound and could have led to the inconsistent effect observed here for the magnitude of the attentional blink, the duration and lack of Lag 1 sparing effects were consistent across the experiments that measured these effects. Furthermore, equivalent T1 accuracy between scene categories suggests that in each experiment, the scenes used were equally detectable and identifiable, limiting how much of a factor the perceptual distance between scenes could play a role. Therefore, future work should use a large stimulus set compared with a small stimulus set to limit the potential confound of using a small stimulus set producing differences unrelated to scene categories. Nevertheless, in the experiments presented, we demonstrate consistent attentional blink duration effects even when expanding the stimulus set used and attribute this effect to urban scenes' engagement of attention.

The current study shows that urban scenes produced a narrow attention allocation and a shorter duration of the attentional blink, likely through speedier disengagement. Speedier disengagement from urban scenes is evidenced in previous research by more and shorter fixations compared with nature scenes (Berto et al., 2008; Valtchanov & Ellard, 2015), and in our study by reduced peripheral dot detection (Experiment 1b). Experiments 2a–c used different stimuli than those used to show a difference in attention allocation in Experiment 1b, therefore, we cannot be certain that the stimuli in Experiments 2a–c lead to the same difference in the allocation of attention as found with the stimuli used in Experiment 1b. However, previous research with varied nature and urban scenes has shown that nature and urban scenes produce these differences in attention allocation (Berto et al., 2008; Menzel & Reese, 2021). Thus, even though not testing for differences in peripheral item detection with the stimulus set in Experiments 2a–c is a limitation, it seems likely given previous literature and Experiment 1b's results, that the set of scenes used in Experiments 2a–c would exhibit similar attention allocations as other scenes from the same categories (Berto et al., 2008; Kaplan, 1995; Menzel & Reese, 2021; Valtchanov & Ellard, 2015). Therefore, our results suggest that urban scenes, as a category, allow for quicker disengagement of attention, leading to a shorter duration of the attentional blink through a narrow attention allocation.

Another explanation for a narrow allocation of attention from urban scenes leading to a shortened attentional blink could be due to more efficient resource use. Previously, a narrow attention allocation has led to more efficient use of attention resources to process targets and inhibit distractors (Guevara Pinto & Papesh, 2019; Lavie, 1995; Tkacz-Domb & Yeshurun, 2017). However, our results do not entirely support this claim. For example, we tested for differences in disengagement in Experiments 2a–c and found consistent effects of urban scenes disengaging attention more efficiently than nature scenes leading to a shorter attentional blink duration. It may be expected that a more efficient processing of targets and inhibition of distractors would lead to a reduced attentional blink magnitude, as others have suggested should occur if this was the case (Chun & Potter, 1995; Dux & Harris, 2007; Dux & Marois, 2009; Olivers & Meeter, 2008; Olivers & Nieuwenhuis, 2006; Raymond et al., 1992; Shapiro et al., 1994). This line of thinking is further supported by Experiment 1a and 1b, where there was a reduced magnitude of the attentional blink likely being due to the smaller stimulus set easing the cost associated with processing stimuli in the attentional blink. It may be that in combination with a speedier disengagement of attention with a small stimulus set (i.e., Experiment 1a showed the same pattern in duration of the blink: urban scenes recovered from the blink by Lag 4 onward), participants could more easily process targets and inhibit distractors due to target/distractor similarity and the ability to group stimuli more easily, which has previously improved attentional blink performance (Guerrero & Calvillo, 2016; Lindh et al., 2019). Thus, the attenuated duration of the attentional blink for urban scenes is likely due to a narrower allocation of attention allowing for a speedier disengagement of attention. Nevertheless, we cannot rule out the possibility that urban scenes narrow attention leading to a shorter attentional blink duration due to more efficient processing of targets and inhibition of distractors but suggest that future studies investigate this distinction.

Even though our study is similar to previous research showing that a narrower attention allocation can be beneficial for target processing and inhibition of distractors (Guevara Pinto & Papesh, 2019), our study differs from this previous work and thus, extends the inference drawn from that study. Guevara Pinto and Papesh (2019) used a single target RSVP search task of real-world objects and increased difficulty by increasing the number of targets participants were told to search for (being told to search for 1–3 targets on any given trial). They also included a peripheral item identification task, which allowed them to determine if participants were narrowing their attention when presented with a more challenging search task (when told to search for 3 items as opposed to 1). Guevara Pinto and Papesh (2019) found that in response to a more challenging search task, participants narrowed their attention allocation to better process the central RSVP stream. The current study used a dual-target RSVP task with nature and urban scenes to demonstrate that different categories of scenes can have different effects on the attentional blink. Furthermore, based on previous research (Berto et al., 2008; Menzel & Reese, 2021; Valtchanov & Ellard, 2015) and Experiment 1b of the current study suggesting that these scenes can allocate attention differently in an RSVP, we attribute this difference in the attentional blink duration to urban scenes narrowing participants' attention. Therefore, evidence from both studies suggests that in response to a task in which stimuli are presented rapidly, it is likely more beneficial to narrow attention to process stimuli more efficiently in an RSVP task or disengage attention in time to prevent disruption from distracting items.

The duration of the attentional blink has been attributed to distractor suppression, with better suppression leading to a shorter attentional blink (Slagter & Georgopoulou, 2013). Our results of a shorter attentional blink for urban scenes combined with previous research (Berto et al., 2008; Valtchanov & Ellard, 2015) showing more frequent shifts of attention in urban scenes are consistent with this interpretation. Additionally, Experiment 1b of the current study also supports a narrow allocation of attention for urban scenes in an RSVP. This narrow allocation likely allows for a speedier disengagement of attention, suppressing distractors from interfering with processing earlier than for nature scenes. Importantly, the attentional blink duration was shorter for urban scenes even with a larger stimulus set, demonstrating that this effect is likely not due to grouping by category (Guerrero & Calvillo, 2016; Lindh et al., 2019), repetition blindness (Arnell & Shapiro, 2011), or negative and positive priming (Harris et al., 2010; Rusconi & Huber, 2018). Therefore, the longer duration of the attentional blink for nature scenes is likely due to urban scenes allowing for quicker disengagement and nature scenes, which elicit a broad spread of attention, requiring more time for disengagement.

Although other differences in how nature and urban scenes are processed may contribute to the difference in the duration of the attentional blink, comparable first target detection performance limits the possibilities. Differences in perceptual difficulty likely did not contribute to the current findings as both scene categories were equally detectable, discriminable, and reportable, evidenced by no difference in first target accuracy between scene categories for all five experiments. Therefore, differences in performance related to the scene category are related to attention engagement for each scene category when trying to detect a second target, after correctly identifying a first. Better Lag 8 performance for nature scenes in Experiment 2a–c could suggest that participants were able to discern the nature scenes more easily compared with the urban scenes. However, attention allocation differences may have also led to differences in reporting the identity of scenes. That is, slower disengagement for nature scenes may allow for better identification of T2 when further outside of the attentional blink window. However, as mentioned in the discussion of Experiments 2a–c, it is also likely that in the three experiments presented there, we may be underestimating the attentional blink, due to not having intervening lags between Lags 5 and 8, as well as lags further out than 8, that may be needed to observe asymptotic behavior (Crewther et al., 2007; MacLean & Arnell, 2012). Thus, the current evidence across five experiments combined with previous literature (Berto et al., 2008; Menzel & Reese, 2021; Valtchanov & Ellard, 2015), points strongly toward the interpretation that the difference in the attentional blink for urban and nature scenes is due to their ability to engage attention differently, with urban scenes allowing for a speedier disengagement of attention.

Theories of the attentional blink

Consistent with the delayed attentional engagement (Nieuwenstein et al., 2005; Zivony & Lamy, 2016) and the efficient disengagement (Chua, 2015) theories, the difference in attention engagement leading to a difference in attentional blink measures seems to be the most likely explanation of the current results. The ability to disengage and reengage attention allows for a shorter duration of the attentional blink, freeing up resources to begin processing a second target. The effective engagement of attention leading to an attenuated attentional blink has been shown in previous work that has outlined how attention might be delayed in reengaging after detecting a first target (Chua, 2015; Nieuwenstein et al., 2005; Zivony & Lamy, 2016). As evidenced by Experiments 1a and 2a–c, urban scenes exhibited no attentional blink starting at Lag 4 and extending to Lag 8, while nature scenes were still exhibiting a blink at Lags 4 and 5 (except in Experiments 1a & 2c where there was no difference between Lag 5 and 8). This ability for urban scenes to produce a shorter duration of the attentional blink was also seen in Experiment 2a–c, where we expanded the stimulus set and generalized to classic designs of the attentional blink (Chun & Potter, 1995; Raymond et al., 1992). Urban scenes may allow participants to disengage and then reengage their attention more effectively compared with nature scenes due to urban scenes producing a narrow attention allocation. Therefore, our results suggest that urban and nature scenes allocate attention differently, with urban scenes producing more efficient disengagement due to a narrow allocation, leading to a shorter duration of the attentional blink. This conclusion supports theories of the attentional blink that rely on efficiently using attention resources.

Most attentional blink theories indicate inhibition of distractors as a critical factor for reducing the attentional blink (see Dux & Marois, 2009 for a review). Some theories specifically formulated the failure to inhibit distractors as a key component of the production of an attentional blink (Chun & Potter, 1995; Dux & Harris, 2007; Olivers & Meeter, 2008; Olivers & Nieuwenhuis, 2006; Raymond et al., 1992). These theories garner support from our study as more frequent shifts of attention in urban scenes (Berto et al., 2008; Valtchanov & Ellard, 2015) suggest the ability to inhibit distractors efficiently due to disengaging attention more quickly from processing the central RSVP stream. More specifically, our results support the bottleneck theory (Chun & Potter, 1995; Dux & Harris, 2007), subsequent overinvestment theory (Olivers & Nieuwenhuis, 2006), and the efficient engagement of attention theories (Chua, 2015; Nieuwenstein et al., 2005; Zivony & Lamy, 2016). Urban scenes' speedier disengagement facilitated the better investment of resources and less interference from distractors disrupting the processing of targets during second-stage processing.

Lag 1 sparing

Unlike previous attentional blink research where the targets are presented in the same spatial location, our study did not observe Lag 1 sparing. This lack of Lag 1 sparing was consistent across all five experiments. However, the lack of Lag 1 sparing was somewhat expected as previous research using scenes has observed an absence of Lag 1 sparing (Marx et al., 2014). Additionally, Lag 1 sparing is not observed when targets are presented in different spatial locations (Visser et al., 1999). Marx et al. (2014) noted that not observing Lag 1 sparing with scenes is likely due to scenes having different spatial features where participants can look at different aspects of the scene to identify it. In the study by Marx et al. (2014), they used animals within images as targets, thus, having the targets in different spatial locations between scenes. In our case, the entire scene was the target, but different regions of each scene could have been used for identification. Thus, it was not unexpected to observe no Lag 1 sparing for either scene category across the five experiments presented here, even when corrected for order swaps.

Differences in the spatial allocation of attention between urban and nature scenes (Berto et al., 2008; Valtchanov & Ellard, 2015) suggests that Lag 1 sparing may differ between urban and nature scenes. However, Lag 1 sparing was not observed in five experiments for both scene categories, even when corrected for order swaps between targets. This lack of Lag 1 sparing suggests that changes in spatial attention affect both scene categories enough to eliminate Lag 1 sparing. It is also possible that the longer SOAs used in the current study eliminated the Lag 1 sparing. Importantly, as noted in previous research, the absence of Lag 1 sparing does not indicate the absence of a valid attentional blink (MacLean & Arnell, 2012). Thus, our results are still consistent with the conclusions drawn about the attentional blink between scene categories.

Conclusion

In conclusion, we investigated how urban and nature scenes differ in attentional resource use and attention allocation. Across four experiments, urban scenes led to a reduced attentional blink duration compared with nature scenes, suggesting that these scene categories are using attentional resources differently. A dot-probe detection task in Experiment 1b suggested that this difference could be due to the allocation of attention in urban scenes being narrower than the allocation of attention in nature scenes. Furthermore, we have provided new evidence for nature and urban scenes producing a difference in attention allocation at short presentation times. Critically, the current study provides additional support for attentional blink theories suggesting the importance of inhibition of distractors and efficient attention engagement in reducing the attentional blink. We also provide evidence that different scene categories can elicit different allocations of attention and could influence how effectively stimuli are disengaged from. Future research on the attentional blink should examine other ways that efficiently disengaging attention can be manipulated within an attentional blink task to determine if this helps to attenuate the attentional blink duration, as our results suggest happened with urban scenes.

Open practices statement The data and materials for all experiments will be available upon publication and Experiments 1a, 1b, and 2a–c were preregistered using AsPredicted: (Exp. 1a: https://aspredicted.org/blind.php?x=cn7fe7 & Exp. 1b: https://aspredicted.org/blind.php?x=48ca33 & Exp. 2a–c: https://aspredicted.org/blind.php?x=3YS_NM6). The AsPredicted for Experiment 1a notes a 15% threshold for first target accuracy by mistake as the threshold for accuracy should have been 30% and was preregistered as such with Experiments 1b and 2a–c.

Data availability Data will be made available upon publication.

The datasets generated during and/or analyzed during the current study are available in the Open Science Framework (OSF) repository (https://osf.io/xn2ue/?view_only=b17de642ce9944a2b800af883f53692a).

Code availability Code to run study using lab.js will be made available upon publication.

Declarations

Ethics approval The Louisiana State University Research Ethics Committee approved this study.

Consent to participate Informed consent was obtained from all individual participants included in the study.

Consent for publication Participants signed informed consent regarding publishing their data.

Conflicts of interest/Competing interests No conflicts of interests or competing interests.

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