The Time Course of Attention Engagement in a Single-stream Rapid Serial Visual Presentation Design

Arianna Schiano Lomoriello[1], **Paola Sessa**[1], **Paul E. Dux**[2],
Mattia Doro[1], **and Roberto Dell'Acqua**[1]

Abstract

■ When two stimuli are presented at the same spatial location in close temporal proximity—typically less than 500 msec apart—the second stimulus is often not perceived, a phenomenon known as attentional blink (AB). This striking failure of visual awareness is thought to reflect limitations in the allocation of attention for the selection and consolidation of visual input. While existing models of the AB differ in their predictions regarding when and why attentional engagement is required, no direct neural correlate has yet been identified to track this process during the AB. Here, we propose that the bilateral N2 posterior contralateral (N2pcb) component of the ERP time-locked to the second stimulus may serve as such a marker. To test this hypothesis, we reanalyzed data from our prior study [Dell'Acqua, R., Dux, P. E., Wyble, B., Doro, M., Sessa, P., Meconi, F., et al. The attentional blink impairs detection and delays encoding of visual information: Evidence from human electrophysiology. *Journal of Cognitive Neuroscience, 27*, 720–735, 2015], in which participants identified target letters embedded in rapid serial visual presentation (RSVP) streams of distractor digits. Each RSVP stream ended with either an unmasked letter (target-present trials) or a digit (target-absent trials). Subtracting ERPs elicited in target-absent trials from ERPs elicited in target-present trials revealed that the N2pcb component persisted even during the AB. These findings suggest that attentional engagement for the second target is largely preserved during the blink, indicating that a disruption of attention is not necessary for the AB to occur, and that post-attentional processing limitations likely play a major role—a conclusion consistent with a specific subset of current AB models. ■

INTRODUCTION

At the interface of sensation and working memory, visual processing must necessarily be selective. This is the case, as visual information that is consciously perceived and available for goal-directed behavior represents only a small fraction of the input reaching the retinae (Bays & Husain, 2008; Cowan, 2001; Luck & Vogel, 1997). The attentional blink (AB; Raymond, Shapiro, & Arnell, 1992) is one of the many key behavioral demonstrations that such selectivity comes at a cost (Wyble, Bowman, & Nieuwenstein, 2009). Three decades of research using the rapid serial visual presentation (RSVP) paradigm, in which two targets (T1 and T2) must be selected out of a stream of distractors for delayed report, have provided a substantial body of evidence that T1 can typically be reported without difficulty, whereas T2 is often missed if it is displayed between 200 and 500 msec after T1. Conversely, if T2 is presented within 100–150 msec of T1, no T2 deficit/AB is observed, a phenomenon referred to as Lag 1 sparing (Potter, Chun, Banks, & Muckenhoupt, 1998). Key indications about the attentional origin of the AB have been obtained by showing the effect is substantially reduced when T1 is ignored (e.g., Raymond et al., 1992), and when the encoding of the targets does not require selection, as in instances where participants are instructed to report all items in a six-item RSVP stream (Nieuwenstein & Potter, 2006).

Three classes of theoretical accounts have been proposed to explain the AB (see reviews by Dux & Marois, 2009; Martens, Wolters, & van Raamsdonk, 2002). These models are often classified under the label of loss-of-control models, diachronic models, and structural (or bottleneck) models of the AB. Although these models differ substantially with reference to the specific processing stage or mental operation whose perturbation results in the AB, they share the core assumption that attention plays a key role in determining this phenomenon.

In loss-of-control models (Taatgen, Juvina, Schipper, Borst, & Martens, 2009; Di Lollo, Kawahara, Ghorashi, & Enns, 2005), active control is required to maintain an input filter tuned to the target features specified in an attention template. This allows for the selection of T1 and T2 among distractors. According to one account (Di Lollo et al., 2005), following selection of T1, control is temporarily diverted to the consolidation of T1 in working memory, causing the input filter to tune passively to the features of the distractor trailing T1. A different account (Taatgen et al., 2009) posits that, upon detection of the post-T1 distractor, control overzealously reacts to the mismatch between distractor and target features by temporarily

---

[1]University of Padova, [2]The University of Queensland

https://doi.org/10.1162/JOCN.a.2393

halting the selection of additional target(s). In this overarching framework, the selection of T2 is only possible if the input filter is reconfigured based on target features, or if target selection is resumed by control mechanisms. The reconfiguration of the input filter based on target features and the resumption of selection by control mechanisms are both time-consuming processes, each taking approximately half a second. If T2 is displayed during the time needed for filter reconfiguration or selection resumption, T2 cannot be selected for consolidation in working memory. If instead T2 is the item following T1, T2 (along with subsequent trailing targets up to the capacity of working memory) can be selected for consolidation due to the absence of distractors between T1 and T2. This results in the absence of reconfiguration of the input filter or selection suspension, yielding sparing from AB.

Diachronic models of attention (Zivony & Eimer, 2022; Wyble, Potter, Bowman, & Nieuwenstein, 2011; Olivers & Meeter, 2008) propose that attentional selection unfolds over time through discrete episodes. An attentional episode is a short-lived window—typically 100–150 msec—during which sensory evidence for a target item is enhanced to support its consolidation into working memory. Before an RSVP stream even begins, recurrent signals from an attention template bias sensory processing toward expected target features (Lamme & Roelfsema, 2000). When T1 appears, evidence begins accumulating for features that match this template. Once this accumulation reaches a critical threshold, the strength of a sensory T1 is enhanced and T1 consolidation can commence. Crucially, once T1 consolidation is underway, attentional enhancement for subsequent items is paused (Wyble et al., 2011), delayed (Zivony & Eimer, 2022), or actively suppressed (Olivers & Meeter, 2008; see also Vul, Nieuwenstein, & Kanwisher, 2008). This disruption underlies the AB. Interestingly, these models predict that if a distractor between T1 and T2 shares features with the target template, it can partially reengage attention, reducing the blink on T2. This prediction has been tested and confirmed by showing the AB is indeed attenuated when such template-matching distractors intervene (Nieuwenstein, 2006; see also Nieuwenstein, Chun, van der Lubbe, & Hooge, 2005). Attentional enhancement in these models is unselective. During an attentional episode, all RSVP items appearing in the attention window receive a general boost in sensory activation. If T2 appears within this window, T2 (as well as subsequent targets up to working memory capacity) is spared from AB and Lag 1 sparing ensues.

Bottleneck models of AB (Jolicœur & Dell'Acqua, 1998; see also Dux & Marois, 2009) are based on evidence suggesting a significant limit in human information processing, represented by a class of mental operations, including working memory consolidation and response selection, that can only be performed in a graded-capacity/serial fashion on separate chunks of information (Dux, Ivanoff, Asplund, & Marois, 2006; Tombu & Jolicœur, 2003; Pashler & Johnston, 1998; Pashler, 1994). When one such operation is in progress on one chunk of information, analogous operations on a different chunk of information are postponed until the other operation is complete. If T2 is presented while T1 consolidation is underway, identification and selection of T2 can occur in parallel, unaffected by T1 consolidation. However, T2 consolidation in working memory must wait until T1 consolidation is complete. While waiting for consolidation of T1 to complete, a fleeting representation of T2 is vulnerable to deletion or replacement by a trailing distractor, resulting in AB. In more contemporary formulations (Dux, Wyble, Jolicœur, & Dell'Acqua, 2014), AB sparing phenomena have been addressed by incorporating the idea that in such cases, successive targets may be processed as temporally integrated (Akyürek, 2025; see also Akyürek et al., 2012) items, which can be encoded as a single coherent percept, allowing them to evade the attentional bottleneck.

Key in the evaluation of such theories, and of our understanding of temporal attention in general, has been the use of EEG as this technique allows the analysis of the neural processing of both targets and distractors with millisecond precision (Vogel, Luck, & Shapiro, 1998). EEG studies investigating attentional engagement in the AB have focused on an ERP component in the EEG signal that is a hallmark of attentional engagement in visual search tasks, namely, N2 posterior contralateral (N2pc). N2pc is a negativity enhancement recorded at parieto-occipital sites contralateral to the visual hemifield containing a lateralized to-be-attended-to target. In the context of visual search tasks, N2pc activity is typically observed between 200 and 300 msec following the onset of the search array. Initially, N2pc was interpreted as reflecting the suppression of distractors in the vicinity of the target (Luck & Hillyard, 1994; however, see Eimer, 1996). However, more recent evidence strongly suggests N2pc reflects attentional engagement for high-level target processing, whether through covert attentional shifts to the target (Foster, Bsales, & Awh, 2020; Tan & Wyble, 2015), consolidation of task-relevant features of the target (Wyble et al., 2020; Zivony, Allon, Luria, & Lamy, 2018), neural enhancement of activation of the target's cortical representation (Doro, Bellini, Brigadoi, Eimer, & Dell'Acqua, 2020), target individuation among distractors (Mazza, Turatto, & Caramazza, 2009), or binding of target features (Luck, 2012). The general strategy across AB/ERP studies has been to insert a laterally displayed T2 using either multistream RSVP designs (Zivony et al., 2018; Losier, Lefebvre, Doro, Dell'Acqua, & Jolicœur, 2017; Akyürek, Leszczyński, & Schubö, 2010; Verleger et al., 2009; Chennu, Craston, Wyble, & Bowman, 2008; Robitaille, Jolicœur, Dell'Acqua, & Sessa, 2007; Dell'Acqua, Sessa, Jolicœur, & Robitaille, 2006; Jolicœur, Sessa, Dell'Acqua, & Robitaille, 2006a, 2006b) or visual search tasks (Lagroix, Grubert, Spalek, Di Lollo, & Eimer, 2015; Pomerleau et al., 2014) while manipulating two key factors known to have a modulatory effect on AB: the lag between T1 and T2 (i.e., short vs. long;

but see Dell'Acqua et al., 2006) and the difficulty of the task required on T1 (e.g., ignore vs. attend T1, or easy vs. difficult perceptual processing of T1).

Of import in the present context, the three models mentioned above make different predictions about the expected N2pc modulations during the AB. Loss-of-control models predict a reduction of N2pc during the AB. This is the case because these models assume attention engagement for selection of T2 is not possible during the AB due to impairment of the attentional filter. Conversely, diachronic models—when no distractor(s) with features matching an attentional template intervene between targets—predict a postponement of N2pc during the AB because attention cannot be reengaged for T2 sensory enhancement until consolidation of the attention episode including T1 is complete. Finally, bottleneck models predict N2pc not to be affected by the AB, for selection of T2 is hypothesized to take place in parallel with consolidation of T1. Across the literature, with one exception (Losier et al., 2017), one finding all N2pc studies on the AB have in common is that N2pc during the blink was never comparable to N2pc outside the AB. N2pc during the AB has been shown to be suppressed in amplitude and, in some cases, subject to a slight latency postponement. In addition, in studies where the difficulty of the task on T1 was manipulated (Akyürek et al., 2010; Robitaille et al., 2007; Dell'Acqua et al., 2006; Jolicœur et al., 2006b), N2pc during the AB was suppressed to a greater extent when the T1 task was more difficult compared with when the task on T1 was easier (see Zivony & Lamy, 2022, for a comprehensive review).

At first sight, these results appear to be in accordance with loss-of-control and diachronic models, as both predict that N2pc during the AB should be impacted compared with N2pc outside the AB. However, this conclusion can be questioned from a number of reasons. First is the use of post-T2 masking in these N2pc studies. With only two exceptions (i.e., Zivony et al., 2018; Losier et al., 2017), in all N2pc studies of the AB, a masking distractor was used to terminate T2 exposure. Although this is intuitively logical because no AB is typically observed for an unmasked T2, a well-established finding in the AB literature is that the rate of intrusions of the post-T2 distractor during the AB is generally high during the AB and virtually negligible outside the AB (Chun, 1997; see also Zivony & Eimer, 2021). The implication of this intrusion asymmetry is that T2-locked ERPs outside the AB truly reflect T2 processing, whereas T2-locked ERPs during the AB are likely to reflect processing of the post-T2 item (or a mixture of T2 and post-T2 processing). This hypothesis has been confirmed for T2-locked P3b activity during the AB by Bourassa, Vachon, and Brisson (2015), who showed that an incorrectly reported (missed) T2 during the AB elicited a P3b that peaked 100 msec later than the P3b elicited by a correctly reported T2, suggesting participants encoded the post-T2 item when they missed the second target. Furthermore, Losier et al. (2017) directly compared N2pc during and outside the AB for masked and unmasked T2s and showed that the post-T2 mask suppressed N2pc both during and outside the AB, suggesting that the mask limits sensory processing of T2, not just attentional engagement for T2 selection. Interestingly, N2pc was fully intact both during and outside the AB when elicited by an unmasked T2, a result compatible with bottleneck models and incompatible with both loss-of-control and diachronic models of the AB. Second, while Zivony et al. (2018) did not used a post-T2 mask and reported a suppressed N2pc during the AB compared with N2pc outside the AB, participants in their dual-stream RSVP design had to encode T1 for later report and make a speeded categorization response to T2, making it hard to disentangle whether the reported N2pc suppression was due to AB or task-switching (e.g., Enns, Visser, Kawahara, & Di Lollo, 2001).

An alternative perspective on N2pc modulations during the AB is offered by considering N2pc as reflecting, perhaps in addition to attention engagement for high-level processing of lateral stimuli, the generation of retinotopic coordinates for an attention shift to a to-be-attended-to target item (e.g., Talcott, Kiat, Luck, & Gaspelin, 2025; Foster et al., 2020; Tan & Wyble, 2015). To put it bluntly, what if the AB disrupts an attention shift toward a to-be-attended-to target, rather than attention engagement for the consolidation of the target in working memory? Although this possibility may appear remote in light of recent demonstrations of the independence of N2pc from attention shifting (e.g., Zivony et al. 2018), N2pc has nonetheless been shown to modulate as a function of stimuli position within the visual field, suggesting that at least one subcomponent of N2pc must be sensitive to space. N2pc amplitude has been shown to vary as a function of stimuli eccentricity (Papaioannou & Luck, 2020) and be subject to significant variations, including polarity reversals, as a function of stimuli vertical elevation relative to the horizontal midline of the visual field (Chen et al., 2025; Bacigalupo & Luck, 2019; Luck, Girelli, McDermott, & Ford, 1997).

Furthermore, even if attention shifting can, at least under particular circumstances, be excluded from the potential factors determining N2pc, a different factor that has never been considered is variations in the spatial focus of attention, which have been shown to play a key role in the selection of T1 and T2 in multistream RSVP designs (e.g., Dell'Acqua, Pascali, Jolicœur, & Sessa, 2003). Studies using Lag 1 sparing to gauge the spatial extent of the focus of attention have shown that participants exposed to multistream RSVP designs adopt, by default, the strategy of broadening their focus of attention to encompass all possible positions where T1 and T2 could be displayed. Upon T1 detection, the focus of attention is held to dynamically narrow to the stream containing T1 in about 100–150 msec (Jefferies & Di Lollo, 2009; Shih, 2000). If T2 is displayed before this critical time window, Lag 1 sparing occurs independently on whether T2 is displayed in the same stream

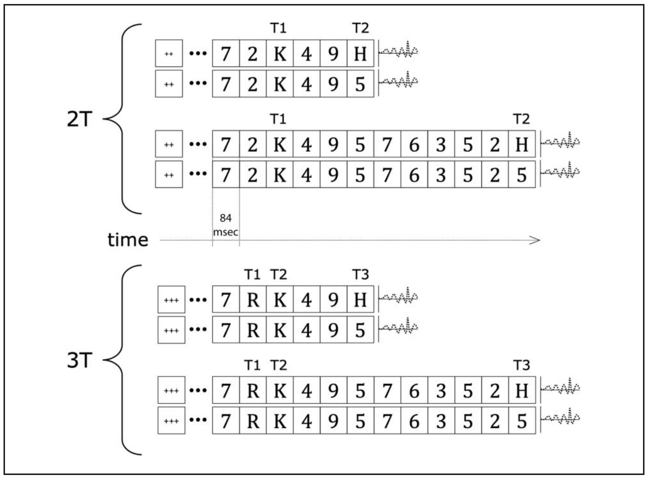

Figure 1. Design of Dell'Acqua et al.'s (2015) experiment. In target-present trials, two or three letters were embedded among digit distractors in 2T or 3T RSVP streams, respectively. Both RSVP streams began with the presentation of a number of centrally displayed "+" signs equal to the number of targets included in the forthcoming RSVP stream, and each character was displayed for 84 msec, immediately followed by the next character. In half of the trials, the last target letter was replaced with a digit distractor, generating a corresponding target-absent RSVP stream. The dotted curvilinear function trailing the last character in each RSVP stream indicates (the onset of) the last character monitored for ERP activity.

as T1 or in a different stream, reflecting a broad spatial focus of attention. Critically, attention focus in multistream RSVP designs has been shown to be subject to significant temporal and spatial variations (Jefferies & Witt, 2019), some of which covary with task difficulty (Zu et al., 2022). These findings suggest that the processing dynamics underlying target selection in multistream RSVP designs, as measured using N2pc, may be substantially different from those observed in more conventional single-stream RSVP designs. While multistream paradigms remain valuable tools for studying a number of aspects of the AB and its interaction with visuospatial attention, single-stream designs offer a more direct measure of temporal attention dynamics under condition of nil spatial uncertainty about stimuli location.

Here, we address this key issue by analytically revisiting a prior attempt of ours at using ERPs to track the time course of working memory consolidation using the single-stream RSVP design illustrated in Figure 1 (Dell'Acqua et al., 2015). Specifically, we embedded a varying number of letters in RSVP streams of digits and systematically manipulated intertarget lag and task load in a context in which the task on the letters was homogeneous (i.e., no task-switching). Participants had to select all letters they could identify in each RSVP stream and report them at the end of each trial with no speed pressure and no constraints on report order. In target-present trials, two or three letters were embedded among digit distractors in two-target (henceforth, 2T) or three-target (henceforth, 3T) RSVP streams, respectively. In half of the trials, the last target letter was replaced with a digit distractor, generating a corresponding target-absent RSVP stream. To manipulate task load, the first and second targets (i.e., T1 and T2) in 3T RSVP streams were always consecutive letters.

We employed a similar design in an earlier behavioral study in which T2 in 2T RSVP streams and T3 in 3T RSVP streams were always trailed by at least one digit distractor and showed AB in 3T RSVP streams was indeed substantially increased compared with AB in 2T RSVP streams (Dux et al., 2014). T1 and T2 in 2T RSVP streams and T2 and T3 in 3T RSVP streams were separated by two distractors (i.e., Lag 3) or eight distractors (i.e., Lag 9). We time-locked ERPs to the onset of the last character in each RSVP stream. In target-present RSVP streams, the last target was never trailed by a digit distractor, so as to avoid contamination of ERPs by activity associated with processing of the post-target digit. Using this approach, ERPs unequivocally reflecting target processing were isolated by subtracting ERPs elicited by a distractor digit in target-absent RSVP streams from ERPs elicited by a target letter in target-present RSVP streams. This subtraction also allowed us to remove EEG signal in phase with the onsets of RSVP items from the resulting difference ERPs. Given the large consensus on the notion that centroparietal P3b activity is a hallmark ERP component indexing working memory consolidation (see Zivony & Lamy, 2022, for a review of P3b findings), we inspected difference ERPs at Cz and Pz for the presence of P3b activity and found results compatible with the predictions made by bottleneck models, as working memory consolidation of the last target—indexed by P3b—was generally postponed at short lag compared with long lag, the more so in 3T RSVP streams, where P3b was also slightly reduced in amplitude compared with P3b in 2T RSVP streams.

The motivation for the present reanalysis of Dell'Acqua et al.'s (2015) EEG data set stems from the fact that, at that time, we did not examine ERP activity other than P3b, because the aim of the article was to explore the time course of working memory consolidation. That is, we did not examine difference ERPs for the presence of a component that has recently been linked to attentional engagement for the selection of stimuli that project bilaterally to visual areas in both posterior cerebral hemispheres, as is the case for foveal stimuli (Nakamura, Chaumon, Klijn, & Innocenti, 2008; Wandell, Dumoulin, & Brewer, 2007; Zeki, 1993; Innocenti, 1986). Doro et al. (2020) termed this component N2pcb, for bilateral N2pc, and provided a series of critical tests linking N2pc elicited by lateral stimuli represented in cortical areas of a single cerebral hemisphere and N2pcb elicited by midline stimuli represented in cortical areas of both cerebral hemispheres (see also Peylo, Glennon, & Sauseng, 2024; Wyble et al., 2020; see Halder, Raya, & Sridharan, 2025, who used N2p to refer to this component). Doro et al. had participant search for a target colored disk among homogeneously colored distractors (singleton search) or among differently colored distractors (feature search) positioned at equal eccentricity around fixation. A target could be displayed in one of the lateral positions or in one of the positions aligned to the vertical midline. Search RTs were faster for singleton as compared with feature search. Compatibly, lateral targets elicited a prototypical N2pc component that, in line with previous studies (Callahan-Flintoft & Wyble, 2017; Feldmann-Wüstefeld & Schubö, 2015; Mazza et al., 2009), onset reliably earlier during singleton search than feature search. A similar onset latency difference between singleton and feature search was also observed for N2pcb elicited by midline targets that was estimated by subtracting either ipsilateral ERPs to lateral targets or bilateral target-absent ERPs from bilateral ERPs to midline targets. Further important tests linking the N2pc and N2pcb were provided by showing that individual onset delays of N2pc and N2pcb were strongly correlated and that, as has been shown for N2pc to lateral targets (Chen et al., 2025; Monnier, Dell'Acqua, & Jolicœur, 2020), N2pcb was fully fledged for midline targets displayed in the lower visual hemifield (i.e., below the horizontal meridian intersecting the point of fixation) and close to nil for midline targets displayed in the upper visual hemifield (see also Dell'Acqua et al., 2022), suggesting an identical response of N2pc and N2pcb to targets' visual retinotopy. These results strongly suggest that N2pcb to bilaterally represented targets reflects the same attentional selection mechanisms as those reflected in N2pc to unilaterally represented targets.

The AB models described above make predictions about N2pcb that are identical to those described for N2pc. Namely, outside the AB, when the last target is displayed at Lag 9, all models predict difference (i.e., target-present minus target-absent) ERPs should be characterized by the presence of a last-target-locked N2pcb, indicating that the selection of the last target is not influenced by AB, and carried out as efficiently in 2T RSVP streams as in 3T RSVP streams. This is because, using a similar design, Dux et al. (2014) have shown AB effects to be over by Lag 8 in both 2T and 3T RSVP streams. However, AB models make substantially different predictions about N2pcb inside the AB, namely, when the last target is displayed at Lag 3. To reiterate, loss-of-control models predict a reduction of N2pcb during the AB; diachronic models predict a postponement of N2pcb during the AB; and finally, bottleneck models predict N2pcb not to be affected by the AB. Here, we test these predictions.

METHODS

Participants

A power analysis based on a two-tailed *t* test using MATLAB simulations (10,000 iterations, $\alpha = .05$) indicated that the original sample of 40 students from the University of Padua (23 females; mean age = 24.8 years, *SD* = 4.6) analyzed by Dell'Acqua et al. (2015) provided sufficient power (.94) to detect the N2pcb component, with an expected effect size (Cohen's $d = 0.8$) congruent with the N2pcb findings of Doro et al. (2020). All students had normal or corrected-to-normal visual acuity, and no history of neurological disorders.

Stimuli

The stimuli were the 22 letters of the English alphabet (all except B, I, O, Z) and the digits 2–9. The stimuli were displayed in light gray (34 cd/m^2) Romantri font against a black (6 cd/m^2) background. Luminance measurements were performed using a Minolta LS-100 chroma meter. Stimuli appeared on a 19-in. CRT monitor running at 60 Hz, placed at a viewing distance of approximately 60 cm from the participant, controlled by an i686 IBM clone computer running MEL 2.0 software. RSVP streams were composed of distractor digits randomly selected from the available set, plus two or three different target letters (T1, T2, and T3) presented in various positions in the stream (see Design and Procedure section). Identical distractor digits in the RSVP stream were always separated by a minimum of three different characters. Each stimulus was displayed for 84 msec and was immediately replaced by the next stimulus (ISI = 0 msec). All stimuli were scaled to fit in a central, square portion of the monitor measuring 1.0° × 1.0° of visual angle.

Design and Procedure

A schematic representation of the experimental design is illustrated in Figure 1. In 3T RSVP streams, T1 and T2 were always consecutive items. The number of distractors preceding T1 was varied randomly across trials from six to 11, and each RSVP stream ended with T2 in 2T RSVP streams or T3 in 3T RSVP stream, which were replaced by a digit distractor when the last target was not displayed. The lag between T1 and T2 in 2T RSVP streams and between T2 and T3 in 3T RSVP streams was manipulated by presenting two (Lag 3, SOA = 252 msec) or eight (Lag 9, SOA = 756 msec) distractors between these targets.

Each participant performed 648 trials, organized into 18 blocks of 36 trials each. Each lag appeared an equal number of times in each block under the constraint that no more than three consecutive trials could be displayed at the same lag. The last target in 2T (i.e., T2) and 3T (i.e., T3) RSVP streams was displayed on half of the (target-present) trials within each block and replaced with a digit distractor in the same position on the other half of (target-absent) trials. Half of the participants started with nine consecutive blocks of 2T RSVP streams, followed by nine consecutive blocks of 3T RSVP streams. The opposite order applied for the other half of the participants.

Each trial began with the presentation of a number of horizontally aligned plus signs in the center of the monitor denoting the number of targets that would appear in the forthcoming RSVP stream (i.e., two or three plus signs, for 2T or 3T RSVP streams, respectively). Pressing the spacebar initiated a trial, causing the plus signs to disappear and the RSVP to start 800 msec later. A question was displayed 800 msec after the end of each RSVP stream, inviting report of the targets by pressing the corresponding keys on the keyboard. Participants were instructed to report all letters in the RSVP streams, with no emphasis on their order or response speed. Feedback on an incorrectly reported target was provided at the end of each trial by replacing the plus sign in the position congruent with target order (from left to right, T1, T2, and T3 when present) with a minus sign. Experimental data were collected after exposing participants to no less than 40 RSVP streams for practice, equally divided between 2T and 3T RSVP streams.

EEG/ERP Recordings and Preprocessing

EEG activity was recorded continuously from 32 active electrodes (Fp1, Fp2, Fz, F3, F4, F7, F8, FCz, C3, C4, Cz, CP1, CP2, CP5, CP6, P3, P4, Pz, O1, O2, Oz, T7, T8, TP9, PO9, PO10, P7, P8 sites) placed on an elastic Acti-Cap (Brain Products), referenced to the left earlobe. Horizontal EOG (HEOG) activity was recorded bipolarly from electrodes positioned on the outer canthi of both eyes. Vertical EOG (VEOG) activity was recorded bipolarly from two electrodes, one positioned above (Fp1) and one positioned below the left eye. Impedance at each electrode site was maintained below 5 KΩ. EEG, HEOG and VEOG activities were amplified, filtered using a band-pass of 0.016–80 Hz, digitized at a sampling rate of 500 Hz, and referenced offline to the average of the left and right earlobes. The EEG was high-pass filtered at 0.1 Hz and low-pass filtered at 30 Hz and then segmented into 1200 msec epochs, starting 200 msec prior to the onset of the last character in the RSVP stream and ending 1000 msec after, and baseline-corrected using the mean activity in the −200 to 0 msec interval. Independent component analysis (ICA) was used to detect and remove blink and saccade components in the continuous EEG recordings (Delorme & Makeig, 2004; Jung et al., 2000). To ensure no residual artifacts remained in any EOG channels, each EEG segment was examined in the interval –200 to 1000 msec relative to the onset of the last item in the RSVP stream for voltage deviations greater than 80 μV in any 150-msec sliding time windows of VEOG activity or a deviation greater than 45 μV in any 300-msec sliding time windows of HEOG activity. EEG segments with residual ocular artifacts were expunged from analysis. The critical analyses considered only EEG segments from trials associated with the correct report of all targets in each RSVP stream. Difference ERPs were generated by subtracting the ERP time-locked to the onset of the last digit distractor in target-absent trials from the ERP time-locked to the last target in corresponding target-present trials. These difference ERPs isolate the response to a target character in the final RSVP position—T2 or T3, in 2T and 3T RSVP streams, respectively—from the response to a digit distractor in the same ordinal position in RSVP streams while also eliminating EEG oscillations in phase with the rate of presentation of RSVP items (11.9 Hz; alpha band).

To rule out the possibility N2pcb latency and/or amplitude variations were in any way determined by P3b variations described in our earlier work (see Introduction section), N2pcb was analyzed in difference ERPs recorded at O1, O2, P7, and P8 sites after performing a second ICA decomposition to remove P3b activity.[1] Individual difference ERPs in each cell of the target number (two vs. three) × lag (3 vs. 9) experimental design were analyzed using singular value decomposition to determine the dimensionality of the signal subspace containing most of the relevant ERP activity. A scree plot of the singular values showed a clear inflection point after the first five ICA components, leading us to retain the first six ICA components, which accounted for 52.8% of the variance. The ICA analysis was thus restricted to this subspace prior to ICA reconstruction of the ERP signal.

Onset and offset latencies of N2pcb activity were estimated using the jackknife approach (Kiesel, Miller, Jolicœur, & Brisson, 2008; Ulrich & Miller, 2001). Latency values were calculated as the time point at which individual jackknifed ERPs reached 25% of the mean peak amplitude. Note that, unlike fractional area analyses, this method is insensitive to selected time windows and to any negativity that emerges after the N2pcb. Relative to a constant criterion (e.g., using an a priori criterion of fixed value, e.g., −1 μV across all lag-by-target-number conditions), this approach allows for a more reliable comparison between conditions that yield peak N2pcb amplitudes of variable sizes (see Zivony & Eimer, 2021, for the use of a similar criterion). Statistical analyses on N2pcb latency values were carried out on individual estimates extracted from jackknifed ERPs following the application of Smulders' (2010) standard solution. Bayesian analyses on individual latency values were conducted to evaluate evidence for the null hypothesis. Bayes factors (BF_{10} or BF_{01}) were calculated using a Cauchy prior distribution with a scale parameter of $r = \frac{\sqrt{2}}{2}$, which represents a balanced compromise between sensitivity and specificity. Because the resulting BF distributions showed positive skewness, we reported median BF values, as they provide a more robust measure of central tendency for nonnormal distributions than mean BF values. We used two approaches to quantify N2pcb amplitude. First, time windows for amplitude quantification were defined based on mean onset and offset latency values in each condition obtained from the N2pcb latency analyses. Second, N2pcb amplitude was also measured separately in a ±40 msec time window centered on the mean N2pcb peak in each condition, as recommended by Luck and Gaspelin (2017). Bayesian *t* tests on amplitude values were conducted using the same Cauchy prior distribution employed for the jackknifed latency analyses.

Current source density (CSD) topographic maps of N2pcb activity were generated using a spherical spline surface Laplacian (order of the splines = 4, regularization parameter $\lambda = 1e{-}5$, conductivity of the skin = 0.33 S/m). We opted for CSD maps because they provide a sharper topography compared with spline-interpolated maps of voltage intensity by reducing blurring effects of volume conduction on the scalp-recorded EEG voltage signal. In addition, CSD maps provide reference-free mapping of scalp-recorded electrical activity, thus making ERP polarity less ambiguous. The CSD approach to scalp topography does not make any assumptions about the neuroanatomy or about the number, orientation, or independence of the underlying neuronal generators. The sign of these estimates directly reflects the direction of the global radial currents underlying the EEG topography, with positive values representing current flow from the brain toward the scalp, and negative values representing current flow from the scalp into the brain. Data and scripts for all psychophysical and EEG analyses can be found at https://osf.io/gbyrc.

RESULTS

Behavior

The average accuracy for reporting each target in target-present RSVP streams is shown in Table 1. Behaviorally, a small but reliable AB (highlighted in gray in Table 1) was observed in 3T RSVP streams. Specifically, accuracy for T3 dropped slightly but significantly when it appeared shortly after T1 and T2 at short compared with long lag. In contrast, T1 report accuracy in both 2T and 3T RSVP streams, and T2 accuracy in 2T RSVP streams remained consistently high across short and long lags, indicating no AB in those cases.

An ANOVA comparing T2 accuracy in 2T RSVP streams and T3 accuracy in 3T RSVP streams as a function of lag showed a main effect of target number, $F(1, 39) = 34.7$, $\eta_p^2 = .466$, $p < .001$; a main effect of lag, $F(1, 39) = 17.3$, $\eta_p^2 = .307$, $p < .001$; and a significant interaction between these two factors, $F(1, 39) = 15.9$, $\eta_p^2 = .290$, $p < .001$. False discovery rate-corrected t tests showed no lag effect for T2 in 2T RSVP streams, $t(39) < 1$, and significantly lower T3 report in 3T RSVP streams at Lag 3 than at Lag 9, $t(39) = 18.6$, $p < .001$. T1 accuracy was higher in 2T than 3T RSVP streams, $F(1, 39) = 256.7$, $\eta_p^2 = .868$, $p < .001$, and this difference was stable across lags, $F(1, 39) < 1$.

Table 1. Mean Probability of Correct Report of Each Target Included in 2T and 3T RSVP Streams as a Function of Lag (T1–T2 Lag in 2T RSVP Streams; T2–T3 Lag in 3T RSVP Streams)

Lag		*3*	*9*
Target	RSVP stream		
p(T1)	2T	.94	.95
	3T	.81	.82
p(T2|T1)	2T	.95	.96
	3T	.94	.94
p(T3|T1 ^ T2)	3T	**.86**	**.96**

Values in the table are contingent on the correct report of preceding target(s). Bolded data: The results indicating a lower probability of correct T3 report at T2–T3 Lag 3 compared with T2–T3 Lag 9, suggesting a relatively small AB was observed in 3T RSVP streams.

Importantly, the small AB observed in 3T RSVP streams occurred even in the absence of a post-target masking distractor. This supports previous findings (Jannati, Spalek, Lagroix, & Di Lollo, 2012; Jannati, Spalek, & Di Lollo, 2011; Ptito, Arnell, Jolicœur, & MacLeod, 2008; Sessa, Luria, Verleger, & Dell'Acqua, 2007; Giesbrecht & Di Lollo, 1998) showing that impaired target report in the AB is not solely due to interference from subsequent stimuli. Instead, the results point to an internal processing limitation when multiple targets appear in rapid succession.

Bottleneck models provide a straightforward explanation for this pattern, as they predict that consolidating both T1 and T2 in 3T RSVP streams takes longer than consolidating T1 alone in 2T RSVP streams (Jolicœur & Dell'Acqua, 1998). During this more extended consolidation time window, sensory evidence for T3 begins to decay, leading to slightly poorer T3 report at the shorter lag. In contrast, loss-of-control and diachronic models offer less precise accounts. The loss-of-control framework posits a temporary failure in attentional filtering due to trailing distractors, but this is unlikely here since distractor types and temporal distribution were the same in both 2T and 3T RSVP streams. Diachronic models, which suggest that attention operates in brief episodes, imply that once an episode ends (after T1 in 2T streams or T1 and T2 in 3T streams), the system cannot quickly reengage to select T3. However, it is not clear according to these models why reengaging attention for T3 in 3T RSVP streams would be less effective than for T2 in 2T RSVP streams.

Difference (Target-present Minus Target-absent) ERPs: N2pcb

The various automated artifact screening procedures resulted in the exclusion of 0.9% of the EEG segments, ranging between 0% and 9.3%. The final sample included all 40 participants originally tested in the experiment. A graphical summary of difference (target-present minus target-absent; see EEG/ERP Recordings and Preprocessing section) ERPs for 2T and 3T RSVP streams at each lag is reported in Figure 2. The following analyses were carried out on difference ERP activity averaged over O1/2 and P7/8 recording sites, to approximate mean activity at PO7/8, an electrode pair missing in the current montage, where N2pcb activity is typically maximal.

The difference ERP functions in Figure 2 show clear-cut evidence for the presence of N2pcb activity unequivocally

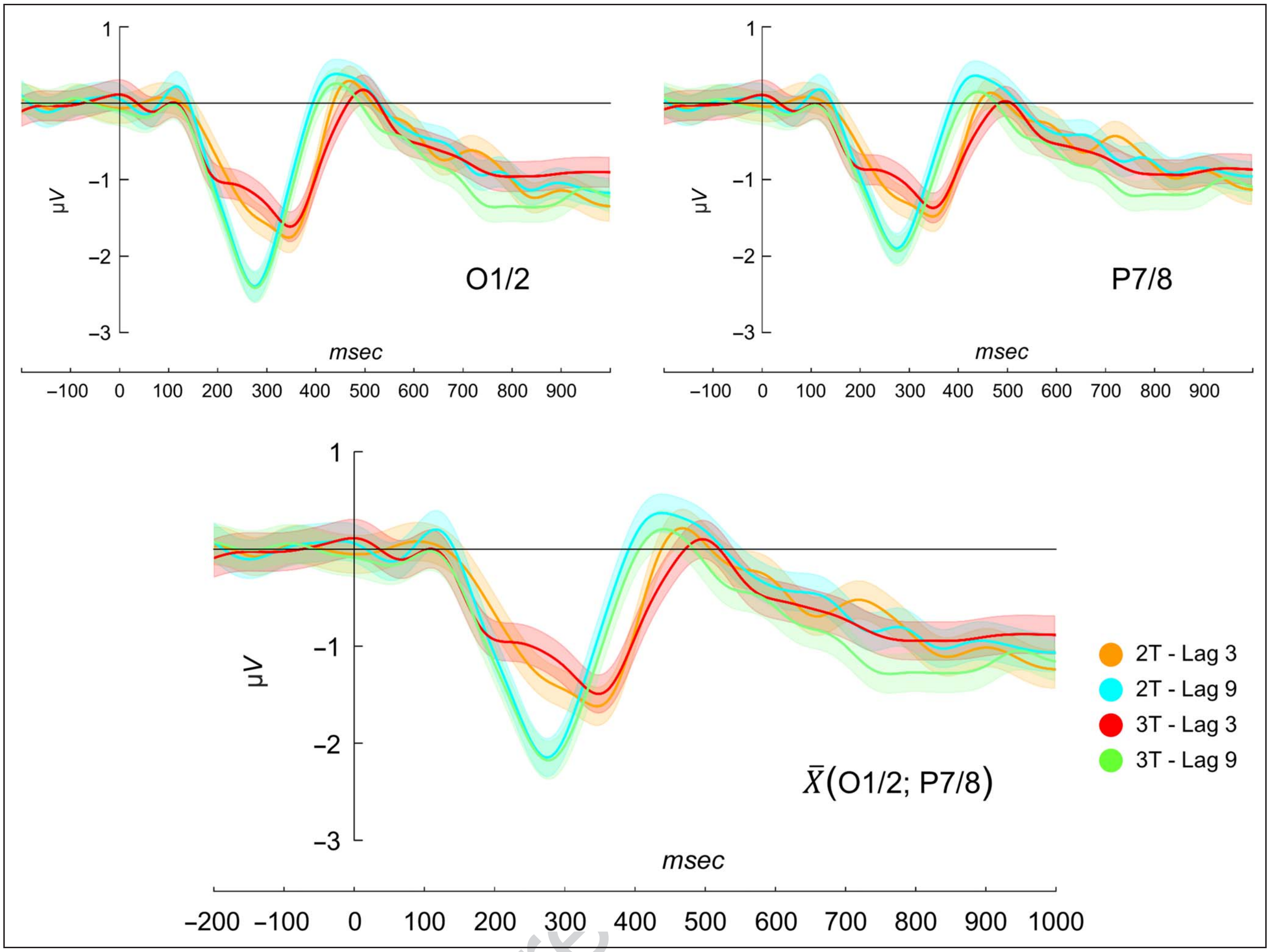

Figure 2. Difference waveforms (target-present minus target-absent) in 2T and 3T RSVP streams, plotted as a function of lag (3 vs. 9). Waveforms were low-pass filtered at 10 Hz for visualization purposes. Difference ERPs are shown separately for the O1/2 and P7/8 recording sites in the upper two panels, and averaged across these recording sites in the lower central panel. All statistical analyses were performed on unfiltered, averaged ERPs.

reflecting processing of the last target in 2T and 3T RSVP streams. Figure 2 suggests the onset of N2pcb was not influenced by either the lag or target number manipulations. The N2pcb onset latency seemed relatively earlier than in prior reports of this component (e.g., Doro et al., 2020), in which N2pcb was, however, observed in visual search tasks. In the present circumstances, RSVP streams were displayed foveally and perhaps critically under condition in which their spatial position, unlike visual search stimuli's, was known in advance. This may have made possible that, at least on a proportion of trials, attentional engagement for last target processing was particularly fast and efficient. In contrast to onset latency, the offset latency of N2pcb seemed slightly postponed at short relative to long lag, with the lag manipulation that also brought about a slight N2pcb amplitude reduction at short relative to long lag. That is, there appeared to be no evidence of an effect of the number of targets prior to the last on either amplitude or latency of the N2pcb. Considering that the AB in 3T RSVP streams was reported to be almost the double of the AB in 2T RSVP streams by Dux et al. (2014), the modest effect of target number on N2pcb in the present context is all the more surprising. N2pcb latency and amplitude values were submitted to analysis to ascertain whether any of these variations were indeed significant.

N2pcb onset latency averaged 164 msec across all conditions. At Lag 9, onset occurred at 168 msec in 2T RSVP streams and 160 msec in 3T RSVP streams; at Lag 3, onset occurred at 179 and 149 msec in 2T and 3T RSVP streams, respectively. An ANOVA on Smulders-corrected onset latencies revealed no effect of target number, $F(1, 39) < 1$; of lag, $F(1, 39) < 1$; or of the interaction between target number and lag, $F(1, 39) < 1$. Bayesian t tests provided substantial evidence in favor of the null hypothesis for both comparisons ($BF_{01} = 5.9$ for lag, $BF_{01} = 2.3$ for target number). These results indicate that the initiation of attentional engagement was unaffected by temporal proximity between targets or by the number of targets in RSVP streams.

In contrast to onset latency, offset latency of N2pcb was influenced by lag. On average, offset latency was 401 msec. N2pcb offset occurred earlier at Lag 9 (366 msec in 2T

RSVP streams, 374 msec in 3T RSVP streams) than at Lag 3 (414 msec in 2T RSVP streams, 415 msec in 3T RSVP streams). An ANOVA revealed a significant main effect of lag, $F(1, 39) = 16.98$, $\eta_p^2 = .303$, $p < .001$, with Bayesian analysis providing very strong evidence for this effect ($BF_{10} = 350.7$). No main effect of target number was observed, $F(1, 39) = 1.50$, $p = .228$; $BF_{10} = 0.3$, nor of a significant interaction between target number and lag, $F(1, 39) < 1$.

Finally, we conducted separate analyses comparing Lag 3 and Lag 9 for each target number condition. These analyses revealed no effect of lag on N2pcb onset latency for either 2T, $F(1, 39) < 1$, $BF_{01} = 3.9$, or 3T, $F(1, 39) < 1$, $BF_{01} = 3.5$, RSVP streams. However, offset latency was significantly affected by lag in both 2T RSVP streams, $F(1, 39) = 12.55$, $\eta_p^2 = .243$, $p = .001$, $BF_{10} = 4.6$, and 3T RSVP streams, $F(1, 39) = 8.86$, $\eta_p^2 = .185$, $p = .005$, $BF_{10} = 3.6$, providing statistical support to the evident anticipated return to baseline of N2pcb at Lag 9 than at Lag 3. This suggests that attentional engagement persisted longer when targets appeared in close succession (i.e., at Lag 3), consistent with the idea that the absence of a post-target masking distractor allowed the sensory trace of the last target to persist longer, thereby prolonging attentional engagement.

Independently of the methods for its calculation, N2pcb amplitude was reliably non-nil in all conditions, all $ts(39) > 4.5$, min $p < .001$, $BF_{10} > 400$. When estimated based on N2pcb latency values, N2pcb amplitude at Lag 9 was −1.24 μV in 2T RSVP streams and −1.31 μV in 3T RSVP streams. N2pcb amplitude at Lag 3 decreased to −1.14 μV in 2T RSVP streams and −1.13 μV in 3T RSVP streams. An ANOVA on latency-based amplitude values showed a main effect of lag, $F(1, 39) = 6.26$, $\eta_p^2 = .634$, $p = .017$, and no effect of target number or of an interaction between lag and target number (both $Fs \leq 1$, min $p = .312$). The Bayesian analysis on latency-based amplitude values offered only "anecdotal" (Raftery, 1995) support for the lag effect ($BF_{10} = 1.9$) and particularly strong support for the null regarding target number ($BF_{10} = 0.2$). When estimated based on a ±40 msec time window centered on the mean N2pcb peak, N2pcb amplitude at Lag 9 was −1.88 μV in 2T RSVP streams and −1.94 μV in 3T RSVP streams. N2pcb amplitude at Lag 3 was −1.39 μV in 2T RSVP streams and −1.27 μV in 3T RSVP streams. An ANOVA was carried out on peak-based N2pcb amplitude values. Consistently with the previous analysis of latency-based amplitude values, the ANOVA on peak-based amplitude values showed a main effect of lag, $F(1, 39) = 10.25$, $\eta_p^2 = .208$, $p = .003$, and no effect of target number or of an interaction between lag and target number (both $Fs \leq 1$, min $p = .527$). Differently, however, from the previous analysis of latency-based amplitude values, the Bayesian analysis of peak-based amplitude values lent substantial support to the lag effect ($BF_{10} = 12.6$), while also strengthening the support for the null regarding target number ($BF_{10} = 0.2$).

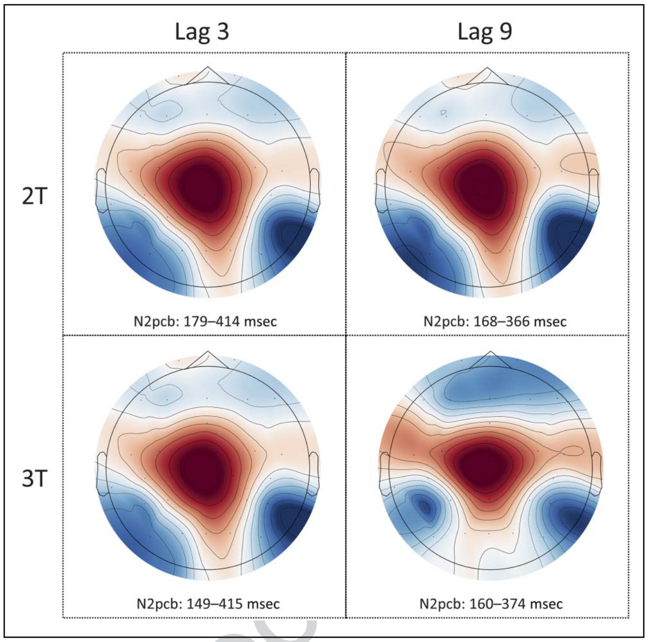

Figure 3. Isocontour CSD topographical maps of N2pcb activity plotted as a function of target number (2T vs. 3T) and as a function of lag (3 vs. 9). The time window of N2pcb activity considered for each map's generation, reported as text below each map, corresponds to the interval between N2pcb onset and offset latencies determined based on jackknifed values.

Despite discrepancies in the foregoing set of results depending on the method used to calculate N2pcb amplitudes, Figure 2 suggests strongly the slight N2pcb amplitude at Lag 3 compared with Lag 9 was real. On the other hand, it must be reiterated this suppression appears to be modest when contrasted with the behavioral findings of Dux et al. (2014), which showed an AB that was nearly twice as large in 3T RSVP streams compared with 2T streams. It must also be noted a model ascribing the AB entirely to perturbations in attentional engagement would predict the suppression of N2pcb amplitude at Lag 3 to be exacerbated for 3T relative to 2T RSVP streams—yet this pattern was not observed. Taken together, the absence of such corresponding N2pcb modulation suggests that attentional engagement remains relatively stable across these conditions.

CSD maps of N2pcb activity as a function of target number and lag are reported in Figure 3.

DISCUSSION

This study provides new electrophysiological insights into the temporal dynamics of attentional engagement during the AB. By reanalyzing ERP data from a single-stream RSVP paradigm, we identified a robust N2pcb component associated with the selection of foveal targets that allowed us to trace the time course of attentional engagement without the confounds of spatial shifts or task-switching.

The behavioral results revealed a modest AB effect in 3T RSVP streams at short lag, consistent with prior findings and indicating a postperceptual limitation in information processing. Critically, this AB occurred despite the absence of post-target masking, supporting the view that the phenomenon arises from endogenous processing constraints. Electrophysiologically, the persistence of N2pcb across both 2T and 3T RSVP streams and across both lags suggests that attentional engagement is not fully abolished during the AB and that a disruption of attention may not be the primary cause of the phenomenon. N2pcb onset latencies were unaffected by either lag or stream complexity, while offset latencies were slightly delayed at short lag, suggestive of prolonged engagement rather than attention disruption. Although our ERP analyses indicated an N2pcb amplitude reduction at short compared with long lag, we observed that, compared with prior behavioral evidence (Dux et al., 2014) of an AB magnitude that was twice as large in 3T relative to 2T RSVP streams, the lack of a corresponding difference in N2pcb amplitude supports the conclusion that the effect was rather modest, pointing to a source of the AB phenomenon that cannot be entirely ascribed to limitations in attentional processing, as suggested by particularly recent work proposing a multisource explanation of the AB (e.g., Halder, Raya, & Sridharan, 2025; Sy, Miao, Marois, & Tong, 2021). An alternative view, according to which the modest N2pcb amplitude reduction determined by the lag manipulation could be symptomatic of a perturbation of attention engagement would be at odds with the observation that task load did not contribute, alone and/or in combination with lag, to exacerbate the N2pcb amplitude reduction observed at short versus long lag. All in all, these findings are more consistent with bottleneck accounts, which posit that attention to target information can operate alongside consolidation processes. However, they do not rule out that attentional mechanisms may contribute under certain conditions. Our use of a single-task, single-stream paradigm further eliminates alternative explanations involving spatial uncertainty or task-switching demands, as seen in previous studies.

The absence of substantial modulations in N2pcb amplitude and onset latency across conditions poses a serious challenge to loss-of-control models. These models explicitly predict that distractor processing disrupts attentional filtering, which should manifest itself as reduced-to-nil N2pcb amplitude during the AB. Particularly problematic for this class of accounts is the present finding that increasing the number of targets from 2T to 3T RSVP streams—which doubled the AB magnitude behaviorally (Dux et al., 2014)—did not correspondingly abate N2pcb amplitude. If filter disruption were the primary mechanism underlying the AB, one would expect this manipulation to produce clear electrophysiological effects on the attentional selection process.

Similarly, diachronic models face explanatory challenges from our results. These models predict attentional deployment to T3 in the present design to be postponed during the AB, as the attentional episode triggered by T1 and T2 must be complete before a new episode can be initiated. However, our N2pcb onset latency data showed no significant lag effect on N2pcb onset latency, suggesting that the timing of attentional engagement remained consistent regardless of processing load and timing. The only timing effect observed was on N2pcb offset latency, which is arguably more consistent with prolonged attention engagement rather than prolonged attention perturbation.

Our findings complement and extend recent electrophysiological investigations of attention dynamics during the AB. For instance, Peylo et al. (2024) reported evidence that target processing during RSVP can occur without distractor suppression, which aligns with our observation that attentional selection (as indexed by N2pcb) persists even when consolidation resources are occupied with preceding targets. Similarly, the sustained nature of N2pcb activity we observed during the AB period resonates with Zivony and Eimer's (2022) proposal that attention deployment operates through temporally extended episodes rather than discrete time points.

Recent theoretical developments in temporal attention also provide context for our results. The "remembering is refocusing" model (Wyble & Bowman, 2019) proposes that attention and working memory interact through excitatory and inhibitory connections, with working memory consolidation generating inhibitory feedback that temporarily suppresses subsequent attentional enhancement. Our finding that N2pcb remains largely intact during the AB suggests that this inhibitory feedback may primarily affect later processing stages rather than early selection mechanisms. Similarly, the integrated framework proposed by Zivony and Lamy (2022) distinguishes between attentional selection, which can operate relatively automatically, and attentional engagement, which requires central resources. Our results support this distinction by demonstrating that selection can proceed normally even when central resources are occupied with the consolidation of previous targets.

A note is in order on prior reports hinting at N2 variations using single-stream RSVP designs. Interpreting these results, and comparing them to the present findings, is complicated because most of those studies introduced an additional task-switching demand between T1 and T2. For example, Sergent, Baillet, and Dehaene (2005) asked participants to classify combinations of "Xs" and "Os" as T1, but then to rate the subjective visibility of number words as T2. Similarly, Nakatani, Baijal, and van Leeuwen (2012) and Kranczioch, Debener, Maye, and Engel (2007) required participants to identify a uniquely colored letter as T1 and then detect an "X" or "O" as T2, while Lasaponara, Dragone, Lecce, di Russo, and Doricchi (2015) asked for a "B/G" letter classification in T1 followed by "X" detection in T2. Such changes in task set could plausibly have contributed to reductions in N2 activity, consistent with the idea that switching goals may temporarily perturb attentional engagement. However, task-switching alone cannot fully explain why several studies consistently reported N2 attenuation during the AB. A broader interpretation is that these N2 reductions may reflect more general constraints on processing efficiency when multiple targets appear in rapid succession, regardless of whether a task switch is required. Indeed, some studies (e.g., Lasaponara et al., 2015; Nakatani et al., 2012) reported bilateral posterior N2 components that were unaffected by lag manipulations, suggesting that attentional engagement signals can persist even when downstream consolidation is impaired. Taken together, these findings indicate that while task-switching is a likely contributor to earlier reports of N2 attenuation, additional attentional or postperceptual limitations specific to those paradigms must also be considered.

In summary, this study supports the idea that post-attentional processing limitations play a central role in the AB and that a disruption to attentional engagement is not strictly necessary for the blink to emerge. Future work using converging methods such as magnetoencephalography or source-localized EEG may further elucidate the cortical architecture supporting this dissociation.

Acknowledgments

The authors thank Elkan Akyürek, Heleen Slagter, and Alon Zivony for their comments on a previous version of this article and Fren Smulders for his help in optimizing the present solution to the analysis of jackknifed values.

Corresponding author: Roberto Dell'Acqua, Department of Developmental Psychology, University of Padova, Via Venezia 8, 35131 Padova, Italy, e-mail: dar@unipd.it.

Data Availability Statement

Data and scripts for all psychophysical and EEG analyses can be found at https://osf.io/gbyrc.

Author Contributions

Arianna Schiano Lomoriello: Data curation; Formal analysis; Validation; Visualization. Paola Sessa: Conceptualization; Supervision. Paul E. Dux: Conceptualization. Mattia Doro: Data curation; Formal analysis; Investigation; Methodology; Software; Visualization. Roberto Dell'Acqua: Conceptualization; Funding acquisition; Project administration; Resources; Supervision; Writing—Original draft.

Funding Information

This work was supported by Grant STPD11B8HM from the University of Padova (https://dx.doi.org/10.13039/501100003500) to R. D. A. and by an Australian Research Council Future Fellowship (https://dx.doi.org/10.13039/501100000923; FT120100033) to P. E. D.

Diversity in Citation Practices

Retrospective analysis of the citations in every article published in this journal from 2010 to 2021 reveals a persistent pattern of gender imbalance: Although the proportions of authorship teams (categorized by estimated gender identification of first author/last author) publishing in the *Journal of Cognitive Neuroscience* (*JoCN*) during this period were M(an)/M = .407, W(oman)/M = .32, M/W = .115, and W/W = .159, the comparable proportions for the articles that these authorship teams cited were M/M = .549, W/M = .257, M/W = .109, and W/W = .085 (Postle and Fulvio, *JoCN*, 34:1, pp. 1–3). Consequently, *JoCN* encourages all authors to consider gender balance explicitly when selecting which articles to cite and gives them the opportunity to report their article's gender citation balance. The authors of this paper report its proportions of citations by gender category to be: M/M = .608; W/M = .255; M/W = .098; W/W = .039.

Note

1. ICA decomposes the ERP signal into statistically orthogonal components, such that P3b amplitude and latency values become structurally uncorrelated with any residual activity in the reconstructed ERP signal. As a result, the reconstructed ERP is no longer suitable for examining any other (e.g., temporal) relationships between P3b and N2pcb. Addressing such intercomponent dynamics requires more sophisticated techniques that can handle temporal misalignments and functional couplings, such as dynamic time warping (Hosseini, Zivony, Eimer, Wyble, & Bowman, 2024). While ICA excels at isolating components, it unavoidably limits the scope of questions one can ask about how those components interact.

REFERENCES

Akyürek, E. G. (2025). Temporal integration as an adaptive process in visual perception, attention, and working memory. *Neuroscience and Biobehavioral Reviews*, *170*, 106041. https://doi.org/10.1016/j.neubiorev.2025.106041, PubMed: 39922439

Akyürek, E. G., Eshuis, S. A. H., Nieuwenstein, M. R., Saija, J. D., Başkent, D., & Hommel, B. (2012). Temporal target integration underlies performance at Lag 1 in the attentional blink. *Journal of Experimental Psychology: Human Perception and Performance*, *38*, 1448–1464. https://doi.org/10.1037/a0027610, PubMed: 22428668

Akyürek, E. G., Leszczyński, M., & Schubö, A. (2010). The temporal locus of the interaction between working memory consolidation and the attentional blink. *Psychophysiology*, *47*, 1134–1141. https://doi.org/10.1111/j.1469-8986.2010.01033.x, PubMed: 20456658

Bacigalupo, F., & Luck, S. J. (2019). Lateralized suppression of alpha-band EEG activity as a mechanism of target processing. *Journal of Neuroscience*, *39*, 900–917. https://doi.org/10.1523/JNEUROSCI.0183-18.2018, PubMed: 30523067

Bays, P. M., & Husain, M. (2008). Dynamic shifts of limited working memory resources in human vision. *Science*, *321*, 851–854. https://doi.org/10.1126/science.1158023, PubMed: 18687968

Bourassa, M.-È., Vachon, F., & Brisson, B. (2015). Failure of temporal selectivity: Electrophysiological evidence for (mis) selection of distractors during the attentional blink. *Psychophysiology*, *52*, 933–941. https://doi.org/10.1111/psyp.12426, PubMed: 25854745

Callahan-Flintoft, C., & Wyble, B. (2017). Non-singleton colors are not attended faster than categories, but they are encoded faster: A combined approach of behavior, modeling and ERPs. *Vision Research*, *140*, 106–119. https://doi.org/10.1016/j.visres.2017.06.013, PubMed: 28859969

Chen, Y., Sessa, P., Brigadoi, S., Petrin, A., Wang, S., & Dell'Acqua, R. (2025). Vertical elevation as a key factor for the neural distinction of target selection and distractor suppression in visual search. *Journal of Integrative Neuroscience*, *24*, 36513. https://doi.org/10.31083/JIN36513, PubMed: 40464468

Chennu, S., Craston, P., Wyble, B., & Bowman, H. (2008). Transient attentional enhancement during the attentional blink: EEG correlates of the ST2 model. In R. M. French & E. Thomas (Eds.), *From associations to rules: Connectionist models of behavior and cognition* (Vol. 17, pp. 115–126). World Scientific. https://doi.org/10.1142/9789812797322_0010

Chun, M. M. (1997). Temporal binding errors are redistributed by the attentional blink. *Perception & Psychophysics*, *59*, 1191–1199. https://doi.org/10.3758/BF03214207, PubMed: 9401454

Cowan, N. (2001). The magical number 4 in short-term memory: A reconsideration of mental storage capacity. *Behavioral and Brain Sciences*, *24*, 87–114. https://doi.org/10.1017/S0140525X01003922, PubMed: 11515286

Dell'Acqua, R., Doro, M., Brigadoi, S., Drisdelle, B. L., Simal, A., Baro, V., et al. (2022). On target selection as reflected by posterior ERP components in feature-guided visual search. *Psychophysiology*, *59*, e14131. https://doi.org/10.1111/psyp.14131, PubMed: 35766411

Dell'Acqua, R., Dux, P. E., Wyble, B., Doro, M., Sessa, P., Meconi, F., et al. (2015). The attentional blink impairs detection and delays encoding of visual information: Evidence from human electrophysiology. *Journal of Cognitive Neuroscience*, *27*, 720–735. https://doi.org/10.1162/jocn_a_00752, PubMed: 25390207

Dell'Acqua, R., Jolicœur, P., Pascali, A., & Pluchino, P. (2007). Short-term consolidation of individual identities leads to Lag-1 sparing. *Journal of Experimental Psychology: Human Perception and Performance*, *33*, 593–609. https://doi.org/10.1037/0096-1523.33.3.593, PubMed: 17563224

Dell'Acqua, R., Pascali, A., Jolicœur, P., & Sessa, P. (2003). Four-dot masking produces the attentional blink. *Vision Research*, *43*, 1907–1913. https://doi.org/10.1016/S0042-6989(03)00308-0, PubMed: 12831753

Dell'Acqua, R., Sessa, P., Jolicœur, P., & Robitaille, N. (2006). Spatial attention freezes during the attention blink. *Psychophysiology*, *43*, 394–400. https://doi.org/10.1111/j.1469-8986.2006.00411.x, PubMed: 16916436

Delorme, A., & Makeig, S. (2004). EEGLAB: An open source toolbox for analysis of single-trial EEG dynamics including independent component analysis. *Journal of Neuroscience Methods*, *134*, 9–21. https://doi.org/10.1016/j.jneumeth.2003.10.009, PubMed: 15102499

Di Lollo, V., Kawahara, J., Ghorashi, S. M. S., & Enns, J. T. (2005). The attentional blink: Resource depletion or temporary loss of control? *Psychological Research*, *69*, 191–200. https://doi.org/10.1007/s00426-004-0173-x, PubMed: 15597184

Doro, M., Bellini, F., Brigadoi, S., Eimer, M., & Dell'Acqua, R. (2020). A bilateral N2pc (N2pcb) component is elicited by search targets displayed on the vertical midline. *Psychophysiology*, *57*, e13512. https://doi.org/10.1111/psyp.13512, PubMed: 31815301

Dux, P. E., Ivanoff, J., Asplund, C. L., & Marois, R. (2006). Isolation of a central bottleneck of information processing with time-resolved fMRI. *Neuron*, *52*, 1109–1120. https://doi.org/10.1016/j.neuron.2006.11.009, PubMed: 17178412

Dux, P. E., & Marois, R. (2009). The attentional blink: A review of data and theory. *Attention, Perception, & Psychophysics*, *71*, 1683–1700. https://doi.org/10.3758/APP.71.8.1683, PubMed: 19933555

Dux, P. E., Wyble, B., Jolicœur, P., & Dell'Acqua, R. (2014). On the costs of Lag-1 sparing. *Journal of Experimental Psychology: Human Perception and Performance*, *40*, 416–428. https://doi.org/10.1037/a0033949, PubMed: 23937218

Eimer, M. (1996). The N2pc component as an indicator of attentional selectivity. *Electroencephalography and Clinical Neurophysiology*, *99*, 225–234. https://doi.org/10.1016/0013-4694(96)95711-9, PubMed: 8862112

Enns, J. T., Visser, T. A. W., Kawahara, J., & Di Lollo, V. (2001). Visual masking and task-switching in the attentional blink. In K. Shapiro (Ed.), *The limits of attention: Temporal constraints in human information processing* (pp. 65–81). Oxford, United Kingdom: Oxford University Press. https://doi.org/10.1093/acprof:oso/9780198505150.003.0004

Feldmann-Wüstefeld, T., & Schubö, A. (2015). Target discrimination delays attentional benefit for grouped contexts: An ERP study. *Brain Research*, *1629*, 196–209. https://doi.org/10.1016/j.brainres.2015.10.018, PubMed: 26477296

Foster, J. J., Bsales, E. M., & Awh, E. (2020). Covert spatial attention speeds target individuation. *Journal of Neuroscience*, *40*, 2717–2726. https://doi.org/10.1523/JNEUROSCI.2962-19.2020, PubMed: 32054678

Giesbrecht, B., & Di Lollo, V. (1998). Beyond the attentional blink: Visual masking by object substitution. *Journal of Experimental Psychology: Human Perception and Performance*, *24*, 1454–1466. https://doi.org/10.1037/0096-1523.24.5.1454, PubMed: 9778831

Halder, S., Raya, D. V., & Sridharan, D. (2025). Distinct neural bases of subcomponents of the attentional blink. *eLife*, *13*, RP97098. https://doi.org/10.7554/eLife.97098, PubMed: 40552489

Hosseini, M., Zivony, A., Eimer, M., Wyble, B., & Bowman, H. (2024). Transient attention gates access consciousness: Coupling N2pc and P3 latencies using dynamic time warping. *Journal of Neuroscience*, *44*, e1798232024. https://doi.org/10.1523/JNEUROSCI.1798-23.2024, PubMed: 38789261

Innocenti, G. M. (1986). General organization of callosal connections in the cerebral cortex. In E. G. Jones & A. Peters (Eds.), *Cerebral cortex* (Vol. 5, pp. 291–353). New York: Plenum. https://doi.org/10.1007/978-1-4613-2149-1_9

Jannati, A., Spalek, T. M., & Di Lollo, V. (2011). Neither backward masking of T2 nor task switching is necessary for the attentional blink. *Psychonomic Bulletin & Review*, *18*, 70–75. https://doi.org/10.3758/s13423-010-0015-3, PubMed: 21327367

Jannati, A., Spalek, T. M., Lagroix, H. E. P., & Di Lollo, V. (2012). The attentional blink is not affected by backward masking of T2, T2-mask SOA, or level of T2 impoverishment. *Journal of Experimental Psychology: Human Perception and Performance*, *38*, 161–168. https://doi.org/10.1037/a0025985, PubMed: 22060143

Jefferies, L. N., & Di Lollo, V. (2009). Linear changes in the spatial extent of the focus of attention across time. *Journal of Experimental Psychology: Human Perception and Performance*, *35*, 1020–1031. https://doi.org/10.1037/a0014258, PubMed: 19653746

Jefferies, L. N., & Witt, J. B. (2019). First unitary, then divided: The temporal dynamics of dividing attention. *Psychological*

Research, *83*, 1426–1443. https://doi.org/10.1007/s00426-018-1018-3, PubMed: 29691650

Jolicœur, P., & Dell'Acqua, R. (1998). The demonstration of short-term consolidation. *Cognitive Psychology*, *36*, 138–202. https://doi.org/10.1006/cogp.1998.0684, PubMed: 9721199

Jolicœur, P., Sessa, P., Dell'Acqua, R., & Robitaille, N. (2006a). Attentional control and capture in the attentional blink paradigm: Evidence from human electrophysiology. *European Journal of Cognitive Psychology*, *18*, 560–578. https://doi.org/10.1080/09541440500423210

Jolicœur, P., Sessa, P., Dell'Acqua, R., & Robitaille, N. (2006b). On the control of visual spatial attention: Evidence from human electrophysiology. *Psychological Research*, *70*, 414–424. https://doi.org/10.1007/s00426-005-0008-4, PubMed: 16184394

Jung, T. P., Makeig, S., Humphries, C., Lee, T. W., McKeown, M. J., Iragui, V., et al. (2000). Removing electroencephalographic artifacts by blind source separation. *Psychophysiology*, *37*, 163–178. https://doi.org/10.1111/1469-8986.3720163, PubMed: 10731767

Kiesel, A., Miller, J., Jolicœur, P., & Brisson, B. (2008). Measurement of ERP latency differences: A comparison of single-participant and jackknife-based scoring methods. *Psychophysiology*, *45*, 250–274. https://doi.org/10.1111/j.1469-8986.2007.00618.x, PubMed: 17995913

Kranczioch, C., Debener, S., Maye, A., & Engel, A. K. (2007). Temporal dynamics of access to consciousness in the attentional blink. *Neuroimage*, *37*, 947–955. https://doi.org/10.1016/j.neuroimage.2007.05.044, PubMed: 17629501

Lagroix, H. E. P., Grubert, A., Spalek, T. M., Di Lollo, V., & Eimer, M. (2015). Visual search is postponed during the period of the AB: An event-related potential study. *Psychophysiology*, *52*, 1031–1038. https://doi.org/10.1111/psyp.12435, PubMed: 25871502

Lamme, V. A. F., & Roelfsema, P. R. (2000). The distinct modes of vision offered by feedforward and recurrent processing. *Trends in Neurosciences*, *23*, 571–579. https://doi.org/10.1016/S0166-2236(00)01657-X, PubMed: 11074267

Lasaponara, S., Dragone, A., Lecce, F., Di Russo, F., & Doricchi, F. (2015). The "serendipitous brain": Low expectancy and timing uncertainty of conscious events improve awareness of unconscious ones (evidence from the attentional blink). *Cortex*, *71*, 15–33. https://doi.org/10.1016/j.cortex.2015.05.029, PubMed: 26142182

Losier, T., Lefebvre, C., Doro, M., Dell'Acqua, R., & Jolicœur, P. (2017). Backward masking interrupts spatial attention, slows downstream processing, and limits conscious perception. *Consciousness and Cognition*, *54*, 101–113. https://doi.org/10.1016/j.concog.2017.04.005, PubMed: 28410866

Luck, S. J. (2012). Electrophysiological correlates of the focusing of attention within complex visual scenes: N2pc and related ERP components. In S. J. Luck & E. S. Kappenman (Eds.), *Oxford handbook of event-related potential components* (pp. 329–360). Oxford, MA: University Press. https://doi.org/10.1093/oxfordhb/9780195374148.013.0161

Luck, S. J., & Gaspelin, N. (2017). How to get statistically significant effects in any ERP experiment (and why you shouldn't). *Psychophysiology*, *54*, 146–157. https://doi.org/10.1111/psyp.12639, PubMed: 28000253

Luck, S. J., Girelli, M., McDermott, M. T., & Ford, M. A. (1997). Bridging the gap between monkey neurophysiology and human perception: An ambiguity resolution theory of visual selective attention. *Cognitive Psychology*, *33*, 64–87. https://doi.org/10.1006/cogp.1997.0660, PubMed: 9212722

Luck, S. J., & Hillyard, S. A. (1994). Spatial filtering during visual search: Evidence from human electrophysiology. *Journal of Experimental Psychology: Human Perception and Performance*, *20*, 1000–1014. https://doi.org/10.1037/0096-1523.20.5.1000, PubMed: 7964526

Luck, S. J., & Vogel, E. K. (1997). The capacity of visual working memory for features and conjunctions. *Nature*, *390*, 279–281. https://doi.org/10.1038/36846, PubMed: 9384378

Martens, S., Wolters, G., & van Raamsdonk, M. (2002). Blinks of the mind: Memory effects of attentional processes. *Journal of Experimental Psychology: Human Perception and Performance*, *28*, 1275–1287. https://doi.org/10.1037/0096-1523.28.6.1275, PubMed: 12542127

Mazza, V., Turatto, M., & Caramazza, A. (2009). Attention selection, distractor suppression and N2pc. *Cortex*, *45*, 879–890. https://doi.org/10.1016/j.cortex.2008.10.009, PubMed: 19084218

Monnier, A., Dell'Acqua, R., & Jolicœur, P. (2020). Distilling the distinct contralateral and ipsilateral attentional responses to lateral stimuli and the bilateral response to midline stimuli for upper and lower visual hemifield locations. *Psychophysiology*, *57*, e13651. https://doi.org/10.1111/psyp.13651, PubMed: 32797636

Nakamura, H., Chaumon, M., Klijn, F., & Innocenti, G. M. (2008). Dynamic properties of the representation of the visual field midline in the visual areas 17 and 18 of the ferret (*Mustela putorius*). *Cerebral Cortex*, *18*, 1941–1950. https://doi.org/10.1093/cercor/bhm221, PubMed: 18065721

Nakatani, C., Baijal, S., & van Leeuwen, C. (2012). Curbing the attentional blink: Practice keeps the mind's eye open. *Neurocomputing*, *84*, 13–22. https://doi.org/10.1016/j.neucom.2011.12.022

Nieuwenstein, M. R. (2006). Top–down controlled, delayed selection in the attentional blink. *Journal of Experimental Psychology: Human Perception and Performance*, *32*, 973–985. https://doi.org/10.1037/0096-1523.32.4.973, PubMed: 16846292

Nieuwenstein, M. R., Chun, M. M., van der Lubbe, R. H. J., & Hooge, I. T. C. (2005). Delayed attentional engagement in the attentional blink. *Journal of Experimental Psychology: Human Perception and Performance*, *31*, 1463–1475. https://doi.org/10.1037/0096-1523.31.6.1463, PubMed: 16366802

Nieuwenstein, M. R., & Potter, M. C. (2006). Temporal limits of selection and memory encoding: A comparison of whole versus partial report in rapid serial visual presentation. *Psychological Science*, *17*, 471–475. https://doi.org/10.1111/j.1467-9280.2006.01730.x, PubMed: 16771795

Olivers, C. N. L., & Meeter, M. (2008). A boost and bounce theory of temporal attention. *Psychological Review*, *115*, 836–863. https://doi.org/10.1037/a0013395, PubMed: 18954206

Papaioannou, O., & Luck, S. J. (2020). Effects of eccentricity on the attention-related N2pc component of the event-related potential waveform. *Psychophysiology*, *57*, e13532. https://doi.org/10.1111/psyp.13532, PubMed: 31953860

Pashler, H. (1994). Dual-task interference in simple tasks: Data and theory. *Psychological Bulletin*, *116*, 220–244. https://doi.org/10.1037/0033-2909.116.2.220, PubMed: 7972591

Pashler, H., & Johnston, J. C. (1998). Attentional limitations in dual-task performance. In H. Pashler (Ed.), *Attention* (pp. 155–189). Hove, United Kingdom: Psychology Press.

Peylo, C., Glennon, M., & Sauseng, P. (2024). Event-related potentials indicate target processing in the absence of distractor suppression during rapid serial visual presentation. *Journal of Integrative Neuroscience*, *23*, 88. https://doi.org/10.31083/j.jin2305088, PubMed: 38812398

Pomerleau, V. J., Fortier-Gauthier, U., Corriveau, I., McDonald, J. J., Dell'Acqua, R., & Jolicœur, P. (2014). The attentional blink freezes spatial attention allocation to targets, not distractors: Evidence from human electrophysiology. *Brain Research*, *1559*, 33–45. https://doi.org/10.1016/j.brainres.2014.02.029, PubMed: 24607298

Potter, M. C., Chun, M. M., Banks, B. S., & Muckenhoupt, M. (1998). Two attentional deficits in serial target search: The visual attentional blink and an amodal task-switch deficit. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *24*, 979–992. https://doi.org/10.1037/0278-7393.24.4.979, PubMed: 9699304

Ptito, A., Arnell, K. M., Jolicœur, P., & MacLeod, J. (2008). Intramodal and crossmodal processing delays in the attentional blink paradigm revealed by event-related potentials. *Psychophysiology*, *45*, 794–803. https://doi.org/10.1111/j.1469-8986.2008.00677.x, PubMed: 18627533

Raftery, A. E. (1995). Bayesian model selection in social research. *Sociological Methodology*, *25*, 111–163. https://doi.org/10.2307/271063

Raymond, J. E., Shapiro, K. L., & Arnell, K. M. (1992). Temporary suppression of visual processing in an RSVP task: An attentional blink? *Journal of Experimental Psychology: Human Perception and Performance*, *18*, 849–860. https://doi.org/10.1037/0096-1523.18.3.849, PubMed: 1500880

Robitaille, N., Jolicœur, P., Dell'Acqua, R., & Sessa, P. (2007). Short-term consolidation of visual patterns interferes with visuo-spatial attention: Converging evidence from human electrophysiology. *Brain Research*, *1185*, 158–169. https://doi.org/10.1016/j.brainres.2007.09.004, PubMed: 17936730

Sergent, C., Baillet, S., & Dehaene, S. (2005). Timing of the brain events underlying access to consciousness during the attentional blink. *Nature Neuroscience*, *8*, 1391–1400. https://doi.org/10.1038/nn1549, PubMed: 16158062

Sessa, P., Luria, R., Verleger, R., & Dell'Acqua, R. (2007). P3 latency shifts in the attentional blink: Further evidence for second target processing postponement. *Brain Research*, *1137*, 131–139. https://doi.org/10.1016/j.brainres.2006.12.066, PubMed: 17258178

Shih, S.-I. (2000). Recall of two visual targets embedded in RSVP streams of distractors depends on their temporal and spatial relationship. *Perception & Psychophysics*, *62*, 1348–1355. https://doi.org/10.3758/BF03212137, PubMed: 11143447

Smulders, F. T. Y. (2010). Simplifying jackknifing of ERPs and getting more out of it: Retrieving estimates of participants' latencies. *Psychophysiology*, *47*, 387–392. https://doi.org/10.1111/j.1469-8986.2009.00934.x, PubMed: 20003147

Sy, J. L., Miao, H.-Y., Marois, R., & Tong, F. (2021). Conscious perception can be both graded and discrete. *Journal of Experimental Psychology: General*, *150*, 1461–1475. https://doi.org/10.1037/xge0001009, PubMed: 33539134

Taatgen, N. A., Juvina, I., Schipper, M., Borst, J. P., & Martens, S. (2009). Too much control can hurt: A threaded cognition model of the attentional blink. *Cognitive Psychology*, *59*, 1–29. https://doi.org/10.1016/j.cogpsych.2008.12.002, PubMed: 19217086

Talcott, T. N., Kiat, J. E., Luck, S. J., & Gaspelin, N. (2025). Is covert attention necessary for programming accurate saccades? Evidence from saccade-locked event-related potentials. *Attention, Perception, & Psychophysics*, *87*, 172–190. https://doi.org/10.3758/s13414-023-02775-5, PubMed: 37612581

Tan, M., & Wyble, B. (2015). Understanding how visual attention locks on to a location: Toward a computational model of the N2pc component. *Psychophysiology*, *52*, 199–213. https://doi.org/10.1111/psyp.12324, PubMed: 25252220

Tombu, M., & Jolicœur, P. (2003). A central capacity sharing model of dual-task performance. *Journal of Experimental Psychology: Human Perception and Performance*, *29*, 3–18. https://doi.org/10.1037/0096-1523.29.1.3, PubMed: 12669744

Ulrich, R., & Miller, J. (2001). Using the jackknife-based scoring method for measuring LRP onset effects in factorial designs. *Psychophysiology*, *38*, 816–827. https://doi.org/10.1017/S0048577201000610, PubMed: 11577905

Verleger, R., Sprenger, A., Gebauer, S., Fritzmannova, M., Friedrich, M., Kraft, S., et al. (2009). On why left events are the right ones: Neural mechanisms underlying the left-hemifield advantage in rapid serial visual presentation. *Journal of Cognitive Neuroscience*, *21*, 474–488. https://doi.org/10.1162/jocn.2009.21038, PubMed: 18564053

Vogel, E. K., Luck, S. J., & Shapiro, K. L. (1998). Electrophysiological evidence for a postperceptual locus of suppression during the attentional blink. *Journal of Experimental Psychology: Human Perception and Performance*, *24*, 1656–1674. https://doi.org/10.1037/0096-1523.24.6.1656, PubMed: 9861716

Vul, E., Nieuwenstein, M. R., & Kanwisher, N. (2008). Temporal selection is suppressed, delayed, and diffused during the attentional blink. *Psychological Science*, *19*, 55–61. https://doi.org/10.1111/j.1467-9280.2008.02046.x, PubMed: 18181792

Wandell, B. A., Dumoulin, S. O., & Brewer, A. A. (2007). Visual field maps in human cortex. *Neuron*, *56*, 366–383. https://doi.org/10.1016/j.neuron.2007.10.012, PubMed: 17964252

Wyble, B., & Bowman, H. (2019). Remembering is refocusing: A method for measuring learning, memory, and attention in the temporal attention and memory (TAM) model. *Frontiers in Psychology*, *10*, 1205.

Wyble, B., Bowman, H., & Nieuwenstein, M. (2009). The attentional blink provides episodic distinctiveness: Sparing at a cost. *Journal of Experimental Psychology: Human Perception and Performance*, *35*, 787–807. https://doi.org/10.1037/a0013902, PubMed: 19485692

Wyble, B., Callahan-Flintoft, C., Chen, H., Marinov, T., Sarkar, A., & Bowman, H. (2020). Understanding visual attention with RAGNAROC: A reflexive attention gradient through neural attractor competition. *Psychological Review*, *127*, 1163–1198. https://doi.org/10.1037/rev0000245, PubMed: 32772529

Wyble, B., Potter, M. C., Bowman, H., & Nieuwenstein, M. R. (2011). Attentional episodes in visual perception. *Journal of Experimental Psychology: General*, *140*, 488–505. https://doi.org/10.1037/a0023612, PubMed: 21604913

Zeki, S. M. (1993). *A vision of the brain*. Oxford, United Kingdom: Blackwell Scientific Publications.

Zivony, A., Allon, A. S., Luria, R., & Lamy, D. (2018). Dissociating between the N2pc and attentional shifting: An attentional blink study. *Neuropsychologia*, *121*, 153–163. https://doi.org/10.1016/j.neuropsychologia.2018.11.003, PubMed: 30419246

Zivony, A., & Eimer, M. (2021). The number of expected targets modulates access to working memory: A new unified account of Lag-1 sparing and distractor intrusions. *Journal of Experimental Psychology: Human Perception and Performance*, *47*, 1543–1560. https://doi.org/10.1037/xhp0000958, PubMed: 34843359

Zivony, A., & Eimer, M. (2022). The diachronic account of attentional selectivity. *Psychonomic Bulletin & Review*, *29*, 1118–1142. https://doi.org/10.3758/s13423-021-02023-7, PubMed: 34918282

Zivony, A., & Lamy, D. (2022). What processes are disrupted during the attentional blink? An integrative review of event-related potential research. *Psychonomic Bulletin & Review*, *29*, 394–414. https://doi.org/10.3758/s13423-021-01973-2, PubMed: 34291430

Zu, G., Sang, H., Zhou, H., Zhang, F., Wu, X., Wang, A., et al. (2022). Flexible attention system: Appearance time of split attention changes in accordance with the task difficulty level. *Attention, Perception, & Psychophysics*, *84*, 2127–2140. https://doi.org/10.3758/s13414-021-02386-y, PubMed: 34820768