IS THE EMOTIONAL BLINK JUST AN ATTENTIONAL BLINK IN DISGUISE?

by

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A thesis submitted to the Faculty of the University of Delaware in partial fulfillment of the requirements for the degree of Master of Arts in Psychology

Fall 2019

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ACKNOWLEDGMENTS

I’d like to thank my advisor, Jim Hoffman, for his advice and mentorship throughout my graduate education; your dedication to the study of psychology remains inspirational to me. The faculty of the Psychological and Brain Sciences Department who nurtured my curiosity about a variety of topics and helped me to become a better researcher. The kind staff of Wolf 108 that helped me and the entire Department to run smoothly. Minwoo Kim, my fellow lab-mates, and peers in the Department, whose friendship and continuous support allowed me to feel at home in this program.

My family, boyfriend, and friends for their care and love throughout my time at the University of Delaware, and without whom my success would not be possible.
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ABSTRACT

In the attentional blink (AB) paradigm, participants attempt to report two targets in a rapidly presented stream of distractors. Emotion induced blindness (EIB) is similar, except that the first target (T1) is replaced by a task-irrelevant, emotional distractor. In both cases, awareness of the second target suffers because attention is captured by T1 (AB) or the emotional distractor (EIB). An important theoretical question is whether attention capture is mediated by the same underlying mechanisms in both paradigms. In the case of EIB, some researchers have suggested that emotional stimuli are processed by a specialized system involving rapid activation of a subcortical pathway targeting the amygdala. This system is not only automatic but acts much faster than the geniculostriate pathway used by task relevant targets in the AB. The claim that attention is captured more rapidly in EIB than AB appears to be supported by a recent finding that lag 1 sparing does not occur in EIB (Kennedy and Most, 2015). Lag 1 sparing refers to relatively unimpaired performance for second targets appearing immediately after the first target. The absence of lag sparing in EIB might reflect the rapid perceptual suppression resulting from specialized processing of emotional pictures. The current study examined this issue using behavioral and ERP measures to directly compare lag 1 performance for EIB and a matched AB paradigm. We replicated the finding of no lag 1 sparing in EIB, but this was also the case for the AB, as well as the neutral distractor control in EIB. Furthermore, the ERP components associated with the emotional distractors in EIB and T1 in AB appeared remarkably similar. These findings show that an absence of lag 1 sparing in EIB cannot be used as an empirical signature of different mechanisms that differentiate the two paradigms.
Chapter 1

INTRODUCTION

Following a single glimpse of a display containing 8-12 alphanumeric characters, human observers can only report the identities of three to four objects, reflecting a severe bottleneck in visual processing (Sperling, 1960). However, if a subset of objects in the scene are designated for report by a spatial cue appearing prior to the display, accuracy for the cued objects is extremely high, showing that a mechanism of visual attention can be used to control which objects in the scene gain access to the bottleneck. These features of a limited capacity bottleneck that follow a selective attention mechanism are clearly demonstrated in the attentional blink (AB) in which there is impaired awareness for the second of two targets when it appears in close temporal proximity to the first target (Raymond, Shapiro and Arnell, 1992; Chun & Potter, 1995). Although the precise mechanisms underlying AB are still in dispute (see Dux & Marois, 2009; Martens & Wyble, 2010; Shapiro, Arnell, & Raymond, 1997 for theoretical reviews) all theories assume that the AB reflects competition by the two targets for a limited-capacity attentional system.

The Two-Stage Model of the Attentional Blink

Chun and Potter (1995) proposed an influential model of the AB that postulates two fundamentally different stages in visual processing (see also Hoffman, 1978, 1979). In this model, all items in the RSVP stream are recognized and identified at an early perceptual processing stage (Stage 1) that operates in parallel and without
capacity limitations. However, awareness of an item (and the ability to report it) requires the item to be attended, allowing it to access a second, limited-capacity stage (Stage 2) of processing. Typically to-be-reported targets in the stream are distinguished by a particular low-level feature such as color. For example, participants might be told that the two targets in the stream are red while the nontargets are chosen from another set of colors. This allows participants to adopt a top-down set for the target feature which will trigger allocation of attention to any red items in the stream.

In the AB, the first target (T1) is reported with high accuracy while the second target (T2) is suppressed when it appears at short lags relative to T1. The failure to report T2 is the result of T1 occupying Stage 2 for an extended period of time, thereby blocking access by T2 which ultimately leaves it vulnerable to masking by subsequent items appearing in the stream. In other words, T2 is fully processed in Stage 1, even at short lags, but it remains unreported because it is unable to access a later stage that is responsible for conscious awareness. This account is known as the late interference theory of the AB and holds that each item, regardless of its status as a target or distractor, is fully processed to include its identity and basic meaning, with suppression of T2 occurring at a later stage in processing that leads to awareness.

Neuroimaging studies (EEG, MEG, fMRI) have corroborated many of the main predictions of the late interference theory. For example, the claim that Stage 1 processing is unaffected in the AB predicts that neural activity associated with perceptual processing of T2 should be the same for trials with and without a blink. This was verified in a study by Vogel, Luck, and Shapiro (1998) which showed that the P1 and N1 components of the event-related brain potential (ERP) that arise from early visual areas in the brain are the same when T2 follows T1 at short and long lags.
In addition, blinked items that couldn’t be reported still elicited an N400 component reflecting semantic processing.

**Emotion Induced Blindness**

The basic structure of the AB paradigm (RSVP of a stream of images in a single location with the stream containing two “targets”) has also been applied to emotional stimuli in order to determine if they automatically capture visual attention. The Emotion Induced Blindness paradigm (EIB) was introduced by Most, Chun, Widders, and Zald (2005) and is similar to the AB with the exception that a task-irrelevant, emotional distractor picture (e.g., a snake) replaces T1 in the stream (see Kennedy et al., 2014; Macleod, Stewart, Newman, & Arnell, 2017; see McHugo, Olatunji, & Zald, 2013 for review). Like the effect of the T1 in AB, an emotional distractor interferes with the report of a closely following target such as a landscape picture rotated 90°. Even though it is not task-relevant and should be ignored, the distractor has emotional salience, as well as physical salience (Hoffman, Kim, Taylor and Holiday, in press), and still manages to capture attention and interfere with a closely following target, presumably because it occupies the same limited-capacity mechanism that is occupied by T1 in the case of the AB.

**Comparing the AB and EIB**

Despite the apparent correspondence between EIB and AB, there is still debate as to whether they reflect competition for the same limited-capacity bottleneck. For example, Most and colleagues (Most & Wang, 2011; Wang, Kennedy, & Most, 2012) have proposed a “spatiotemporal competition” account of EIB that suggests that emotional distractors, unlike the task-relevant T1 in the AB, compete with targets at
early, perceptual processing stages. They report that participants who are monitoring two simultaneous streams show larger interference when the target follows an emotional distractor in the same stream relative to the different stream condition. Non-emotional or neutral distractors did not appear to show this dependence on a shared location. Most and colleagues interpreted this spatial location effect as evidence that suppression in the EIB may be occurring in early visual representations where location is a relevant property, rather than during central processing stages where location information may have been discarded. Thus, they argue, EIB may reflect rapid, specialized, emotion-based, suppression of perceptual processing of the following target that does not occur with non-emotional stimuli in the AB.

Lag 1 Sparing

In further support of rapid attention capture in EIB, Kennedy and Most (2015) reported an absence of lag 1 sparing in the EIB paradigm. Lag 1 sparing in the AB refers to good performance for a T2 appearing immediately following T1 (i.e., at lag 1; e.g. Chun, & Potter, 1995; Hommel & Akyurek, 2005; for review see MacLean & Arnell, 2012). According to the central interference theory of the AB, lag 1 sparing occurs because the attentional window that is opened by T1 remains open long enough to allow entry by T2 when it occurs immediately after T1 (Dux, & Marois, 2009). Kennedy and Most (2015) assume that lag 1 sparing is an inevitable feature of the AB, in which case its absence in EIB lends credence to the claim that the two paradigms are driven by different underlying mechanisms. They account for the absence of lag 1 sparing in EIB by assuming that emotional stimuli suppress competing information at early perceptual processing stages, allowing for rapid suppression of information that is in close temporal and spatial proximity to the negative picture. Other researchers
have suggested that rapid attentional capture by emotional stimuli is mediated by a subcortical pathway targeting the amygdala which has extensive connections with various areas in the ventral visual stream as well as prefrontal cortex (LeDoux & Phelps, 1993). This system has been characterized as providing particularly rapid processing of emotional stimuli, potentially allowing for fast attention capture and rapid suppression of targets presented at lag 1 in EIB.

However, lag 1 sparing is not a uniform finding in the AB literature. Visser, Bischof, and Di Lollo (1999) reviewed over a hundred published AB studies and found that lag 1 sparing occurred in approximately half of them. Generally, lag 1 sparing occurs when two criteria are met: 1. T1 and T2 occur in the same spatial location, and 2. there is either no task switch between targets, or the task switch involves a single dimension. Examples of a task switch would be making a judgment based on T1’s physical features, followed by a semantic judgment about T2. Visser et al. suggest that a task switch requires a reconfiguration of the attentional set following T1, in which case the lag 1 condition may not leave sufficient time for this reconfiguration to occur before the occurrence of T2 resulting in a failure to select it. It is unclear how to apply this reconfiguration hypothesis to EIB because participants don’t have an explicit task for the irrelevant emotional distractors and therefore would not have to reconfigure their set before the arrival of T2. Therefore, one might predict lag 1 sparing, which is not what Kennedy and Most (2015) found. On the other hand, participants may have adopted a “task” of actively attempting to ignore the emotional distractor, in which case, they do have to switch tasks to select the following target resulting in an absence of lag 1 sparing.
Additionally, lag 1 sparing is affected by the type of stimuli used, with little or no sparing for pictorial stimuli compared to the alphanumerical stimuli commonly used in most AB studies (but see Potter, Wyble, Pandav & Olejarczyk, 2010, for an exception). For example, Dux and colleagues (Dux and Harris, 2007; Harris, Benito, & Dux, 2010), used line drawings of objects for T1 and T2 with these targets being defined by the same color (red objects among black distractors) and task (identification). They reported a complete absence of lag 1 sparing even though there was no task switch.

Livesey and Harris (2011) directly examined the extent of lag 1 sparing for letters, line drawings of objects and pictures of objects using the same tasks for T1 and T2 (they both involved recognizing red targets among black or gray scale distractors). They found a “modest” amount of lag 1 sparing (performance greater at lag 1 relative to lag 2) for both picture conditions, but much larger sparing for the letter stimuli. They concluded (p. 2122) that “the strong lag-1 sparing effects assumed to be the norm in previous studies might turn out to be relatively specific to highly practiced stimuli, such as letters and digits (and, perhaps, to some extent, familiar faces)”. Together these results show that even when task switching is not a factor, the amount of lag 1 sparing is partially dependent on the type of stimuli used. These considerations suggest that one might find little or no lag 1 sparing in a typical EIB experiment using scene images regardless of whether there are different underlying mechanisms at work in EIB and AB.

**Current Study**

To determine if lag 1 sparing is a systematic difference between EIB and AB we must first determine whether lag 1 sparing occurs during the AB using pictorial
stimuli like those employed in EIB studies. The above review suggests that we should expect little or no sparing with pictorial stimuli, which would suggest that the absence of lag 1 sparing in EIB might be not be “special” after all, eliminating its use as a signature difference between AB and EIB. In addition, the EIB paradigm uses neutral distractor pictures which act as a control because, like the negative distractors, they contain people and animals but without emotional valence. These pictures also produce a blink but one that is smaller than that associated with the negative pictures.

The neutral distractor blink can also be examined for the presence or absence of lag 1 sparing. If the absence of lag 1 sparing reported by Kennedy and Most (2015) is a result of specialized processing of emotional distractors, we shouldn’t find the same result for the neutral distractor pictures. Note that this is a more telling comparison than one involving AB because whatever task switching might or might not be associated with task-irrelevant, negative distractors would also presumably hold for task-irrelevant, neutral distractors. In both cases, participants are trying to ignore a salient distractor. The current study directly compares performance at lag 1 for EIB and AB using identical scene stimuli and targets. The question is whether task-relevant targets in AB and task-irrelevant neutral distractors in EIB also produce an absence of lag 1 sparing. If so, it would call into question the claim that emotional stimuli are unique in producing an absence of lag 1 sparing.

EEG Components

We also recorded the N2 component of the ERP during these tasks. The N2 elicited by non-lateralized, attention-capturing stimuli, as used here, is probably related to the N2pc (N2, posterior contralateral) which is a posterior negativity appearing over occipital-temporal cortex contralateral to the visual field of the
stimulus (see Luck, 2011). The latency of this component provides a very precise (millisecond precision) measure of the latency of attention allocation (Grubert, Fahrenfort, Olivers & Eimer, 2017). If emotional stimuli capture attention faster than unemotional stimuli, they should elicit shorter latency N2 components as well.
Chapter 2

TESTING THE AB AND EIB

Study Design

The EIB vs. AB manipulation was implemented as a between-subjects factor. All participants were University of Delaware students (EIB: 20 participants, 10 females, mean age: 20.2; AB: 21 participants, 14 females, mean age: 20.5) and they received course credit, or were recruited and paid $10/hour for their participation in this study. Each participant was right-handed and had normal or corrected to normal vision. We also excluded individuals with self-reported anxiety disorders who might find the negative images used in the EIB study disturbing. Three participants from the EIB study, and five from the AB study were excluded from further analysis due to noisy EEG recordings (greater than 20% of segments rejected due to noisy channels, eye-blips or eye movements). Two participants (one each in EIB and AB paradigms) were excluded due to malfunctioning of the eye-tracker. Finally, one participant in the EIB paradigm withdrew before finishing. The following analyses are based on the remaining 15 participants in each study.

Materials

Participants were tested individually and viewed images displayed on a SAMSUNG 2233RZ 22” LCD Monitor with a 1,680 X 1,050-pixel resolution and 60-Hz refresh rate. A chin rest was used to fix viewing distance at 70 cm. Each image was 480 x 360 pixels and subtended a visual angle of 10.4° x 7.8°. The experiment was programmed with Python version 2.7 (Python Software Foundation, http://www.python.org; van Rossum & Drake 1995) using PsychoPy software extensions (Peirce, 2007; Peirce, 2009). Eye movements were monitored with an
Eyelink 1000 eye tracker using the Eyelink Toolbox extensions (SR Research, Ontario Canada) for Python. Eye position was sampled at 500-Hz. An eye movement away from fixation was defined as three consecutive eye samples that were more than 1.4 degrees of visual angle (dva) from the fixation point.

**Procedure**

The EIB experiment consisted of 648 trials divided into eight blocks of 81 trials each. Prior to the beginning of the actual study, participants were informed that they would be viewing emotionally charged pictures and were shown examples of these images with the option to withdraw from the study at any point if they became uncomfortable while viewing them. They then completed twelve practice trials without negative or neutral distractors to become accustomed to the task. Each trial began with a fixation cross appearing in the center of the screen which remained visible until participants initiated the trial by clicking a mouse button. They were then shown a sequence of 25 pictures at a rate of 10/sec. Each picture was shown for 100 ms with no inter-stimulus interval. Distractors appeared randomly at positions 3-6 in the sequence and were followed by a target picture at lags 1 (100 ms), 3 (300 ms), or 8 (800 ms).

The filler pictures were drawn randomly from a collection of 184 images of landscapes, cityscapes, etc. chosen from publicly available sources (Google images, etc.). Importantly, none of these images portrayed humans or animals. One of three types of distractors appeared on each trial: negative, neutral or baseline (see Figure 1A). Baseline distractors were randomly chosen from the set of filler pictures and were not distinguishable from the other filler images in the stream. Negative distractors depicted violence, medical trauma, and threatening animals. Neutral
distractors also depicted people and animals but without any obvious emotional content. Negative and neutral images were primarily drawn from the International Affective Picture System (Lang, Bradley, & Cuthbert, 2001) on the basis of ratings of valence and arousal and were supplemented with similar images from publicly available sources.

Target images were drawn from the same set of pictures used for filler images and were rotated 90° left or right. Participants indicated the rotation direction at the end of the sequence by clicking on one of two on-screen buttons and rated their confidence using a three-point scale (“Sure”, “Somewhat Sure”, “Guess”). The combination of distractor location (3-6), distractor type (negative, neutral, baseline), lag (1,3, 8) and target orientation (left vs. right) occurred equally in random order across trials. Performance was measured as accuracy in reporting target orientation. An example lag 1 trial is shown in Figure 1B for both of EIB and AB.

The AB study used a nearly identical procedure, except the task-irrelevant distractor pictures were replaced with a task-relevant target (T1). There were 576 trials separated into six blocks. Participants began with a practice sequence of twenty trials that increased in presentation rate from 5/sec to 10/sec to allow participants to become comfortable with the procedure. The RSVP stream was comprised of the same filler scene images as the EIB paradigm with the addition of a T1. T1 was an outdoor scene image with a tractor in the foreground; the task was to identify the color (green vs. not green) of the tractor. The T2 task was the same as that used in the EIB paradigm and required participants to determine the orientation of a scene picture that was rotated 90° to the left or right. T2 could appear at lags 1, 3 or 8 relative to T1, just as in EIB. At the end of the sequence, participants used on-screen buttons to choose the tractor
color as green or not green (each was equiprobable) and the orientation of T2 (left vs. right), along with their confidence in their T2 decision. In alternating blocks of trials, T1 was either present or absent (similar to the distractor in EIB).

Figure 1  
A. Examples of three distractor types for EIB: negative, neutral or baseline. In the AB experiment, T1 was a picture of tractor and participants had to identify its color (green or not green). B. Trial sequence for both EIB and AB. In both paradigms, the target/T2 was a rotated scene picture appearing at lag 1, 3 or 8 after the distractor (EIB) or first target (T1; AB).
**EEG Recording**

EEG recording procedures were the same across both paradigms. EEG was recorded using an Electrical Geodesics Inc. system (EGI; Eugene, OR) with a 129 channel Hydrocel Sensor Net. Individual sensor impedances were kept below 50–75 kΩ as recommended by the manufacturer. The data were referenced online to the vertex, band-pass filtered from 0.01 to 80 Hz, and digitized at 200 Hz. Subsequent processing was performed offline using EGI Net Station 4.1.2 software. The data were low-pass filtered using a cutoff of 40 Hz, and were segmented using an epoch beginning 200 ms prior to onset, and ending 1,400 ms after onset. Channels were marked as bad if the maximum voltage range exceeded 100 μV, and segments were removed if more than 10 channels were marked as bad. Trials containing eye blinks (threshold = 100 μV) or eye movements (threshold = 70 μV) were also rejected. For the remaining segments, bad channels were replaced by interpolating from surrounding channels. Finally, the segments were averaged, re-referenced to the average reference, and baseline corrected using the 100-ms pre-stimulus interval.

ERPs elicited by stimuli appearing in an RSVP stream contain overlapping activity from other stimuli in the stream. The overlapping components can be eliminated using appropriate subtractions or difference curves (Kennedy et al., 2014; Luck, Woodman, & Vogel, 2000). To isolate ERP components elicited by the distractor pictures, the baseline lag 8 condition was subtracted from each distractor’s (neutral or negative) lag 8 condition. For example, the negative distractor ERP was obtained by subtracting the baseline lag 8 waveform from the negative lag 8 waveform. In the AB condition, the T1-absent lag 8 condition was subtracted from the T1-present lag 8 condition to isolate the ERP elicited by T1.
The sensors and time windows used to measure the N2 component were based on those used in Kennedy et al. (2014). We quantified N2 amplitude by averaging over three contiguous sensors in each hemisphere in the vicinity of 10-20 locations T5 and T6 (64, 68, and 69 in the left hemisphere; 89, 94, and 95, in the right). These locations are in good agreement with previous research on the N2 (e.g., Schupp, Junghöfer, Weike, & Hamm, 2003a).
Chapter 3

STUDY RESULTS

Behavioral Results

Figure 2 depicts mean target (EIB) and T2 (AB) accuracy as a function of lag and distractor type for EIB and T1 presence/absence for AB. Only trials when participants correctly completed the T1 task and rated their response as “Sure” or “Not Sure” were included in the analyses; trials that were marked “Guess” or were incorrect were excluded. Data for each condition were analyzed with separate repeated measures ANOVAs. For EIB, the factors were distractor type (negative, neutral and baseline) and lag (1, 3 and 8). There was a significant effect of distractor type, $F(2, 28) = 36.55, p < 0.001, \eta^2_p = .723$, with lowest performance occurring in the negative distractor condition ($M = 80.12, SE = 1.53$), intermediate in the neutral condition ($M = 84.81, SE = 1.95$), and highest with baseline distractors ($M = 87.90, SE = 1.86$). Post-hoc pairwise comparisons using the least significant difference test (LSD) revealed significant differences between all three distractor types (all $p$’s < 0.001). The LSD test is justified in this case, without an adjustment for multiple comparisons, because the independent variables have three levels and they followed a significant main effect (see Cardinal & Aitken, 2006)
Figure 2  Accuracy in reporting targets in EIB and T2 in AB experiments as a function of lag and distractor type (EIB) or task (AB). Error bars depict standard error.

The effect of lag was also significant, F(2, 28) = 40.25, p < 0.001, \( \eta_p^2 = .742 \). Post-hoc comparisons showed that lag 1 performance (M = 80.4, SE = 1.70) was significantly worse than both lag 3 (M = 84.28, SE = 2.02) and lag 8 (M = 88.16, SE = 1.58; all p’s < 0.01), replicating the lack of lag 1 sparing found by Kennedy and Most (2015). Lag 3 was also significantly worse than lag 8 (p < 0.001).

Additionally, there was a significant interaction between distractor and lag, F(4, 56) = 14.503, p < 0.001, \( \eta_p^2 = .509 \). This significant interaction was analyzed with separate ANOVAs at each lag. At lag 1 there was a significant effect of distractor type (F(2, 28) = 55.9, p < 0.001, \( \eta_p^2 = .80 \); post-hoc tests showed that all pairwise comparison were significant (p’s < 0.001). At lag 3, there was a significant effect of distractor type (F(2, 28) = 9.6, p = 0.001, \( \eta_p^2 = 0.407 \)); post-hoc tests showed that performance in the negative distractor condition differed significantly from both
baseline and neutral conditions (p = .001, and p = 0.011, respectively), however, there was no difference between neutral and baseline distractors, p = 0.293. By lag 8, there was no significant effect of distractor type (F(2,28) < 1, p = 0.83). In summary, the results replicate Kennedy and Most’s (2015) finding of no lag 1 sparing in EIB.

The pattern of results was remarkably similar for the AB paradigm, which also showed an absence of lag 1 sparing. Performance in the T1 present condition was lowest at lag 1 and steadily improved as lag was increased to 3 and 8. A repeated measures ANOVA with factors of Lag (1, 3, and 8) and T1 present/absent, found a significant main effect of lag F(1, 28) = 34.78, p < .001, ηp2 = .713; post-hoc comparisons revealed significant differences between all lags (all p’s < .001). Additionally, as expected, T1 presence dramatically reduced T2 accuracy relative to T1 absent, F(1, 14) = 142.4, p < .001, ηp2 = .91, Mabsent = 88.85 SE = 1.09, Mpresent = 74.61 SE = 1.19. There was also a significant interaction between lag and T1 condition, F(2, 28) = 55.61, p < .001, ηp2 = .799. Follow up ANOVAs at each lag revealed a significant effect of T1 presence at lag 1 (F(1, 14) = 196.76, p < 0.001) and lag 3 (F(1, 14) = 43.37, p < 0.001) but no effect at lag 8 (F(1, 14) = 2.98, p = 0.106).

The behavioral data indicate that there was no lag 1 sparing following the negative and neutral distractors in EIB and the T1 in AB. These results show that an absence of lag 1 sparing is not uniquely associated with task-irrelevant, negative distractors in EIB but is also true of non-emotional stimuli which capture attention, either because they are task relevant (AB) or because they are task-irrelevant but physically salient (neutral distractors in EIB).
**ERP Results**

The N2 component elicited by nonlateralized stimuli, as in the present paradigm, appear to be similar to the N2pc elicited by lateralized stimuli which is thought to reflect attention capture (Hickey, McDonald, & Theeuwes, 2006; Luck, 2012), and should provide information about whether capture is particularly rapid for negative distractors. Typically, the amplitude of an ERP component is quantified as the average voltage in a window (in the case of the N2, a window extending from 185–275 ms following the onset of the distractor or target). Although average voltage is the preferred measure of amplitude (Luck, 2014), in this instance it would produce a distorted value for the neutral distractor. The N2 elicited by the neutral distractor has a shorter duration than the negative distractor and reverses polarity before the end of the measurement window (see Kennedy et al. 2014 for similar results). We dealt with this problem by instead using the *peak negativity* in the window as an amplitude measure. Figure 3 shows the N2 components elicited by the negative and neutral distractors in EIB and the T1 in AB for all subjects. While visual inspection shows clear differences across the negative (M = -1.69 µV, SD = 1.6 µV), neutral (M = -1.09 µV, SD = 1.36 µV) and T1(M = -2.00 µV, SD = 1.18 µV) N2, no comparison of amplitudes reached significance (all p’s > 0.05).
Despite these null findings agreeing with the behavioral pattern for this study, the N2 to the negative and neutral distractors were smaller than expected compared to previous results in the literature (ex. Kennedy et al., 2014). Upon further examination of the individual participant data, three subjects were found to have a positive component occur during the N2 time window in EIB. This positivity diminished the grand average amplitude and lead to a distorted view of the N2 to the negative and neutral distractors. Figure 4 shows the average N2 waveform for the remaining 12 participants in EIB. Excluding these participants did not change the statistical results (all p’s > 0.05 for all comparisons), but the amplitude of the N2 to the negative (M = -2.15 µV, SD = 1.38 µV) and neutral (M = -1.6 µV, SD = 0.86 µV) distractors did appear more typical, and overall more similar to the N2 to T1. It’s unclear from the current study design what cognitive process this positivity may index, especially since the three participants showed a typical EIB pattern behaviorally. Furthermore, no
participants in the AB study showed this pattern. Further examination is required to
determine if this positivity is related to attention capture by emotional images used in
EIB or may indicate a more general process related to withdrawing attention away
from a task-irrelevant distractor.

Figure 4  N2 components for T1 in AB, and negative and neutral distractors in EIB
excluding three subjects with large positivity during the time window of
the N2.

A final comparison of the onset of the N2 was used to evaluate if a negative
distractor captures attention more rapidly than a task-relevant T1 in AB. We used a
measure of fractional peak amplitude to determine the N2 latency in these studies.
Fractional peak amplitude, specifically 50% of the peak amplitude used here, requires
finding the peak amplitude during a time window and working backward to determine
the point in time when that specific fraction is reached for each subject (Luck et al.,
2014). This has been shown to be a reliable measure of onset latency, and particularly
useful in data sets such as this where there is a difference in component duration across conditions that could lead other latency measures (such as fractional area) to falsely delay the onset of the N2 to the negative distractors and T1 (Luck, 2014; see Kiesel, Miller, Jolicoeur & Bisson, 2008 for comparison of multiple onset measurements). When we compared across EIB and AB using all 15 subjects from EIB, there was no difference in N2 onset between the negative distractors (M = 194.67 ms, SD = 30.54 ms) and T1 (M = 208.51 ms, SD = 22.7 ms), t(28) = -1.41, p = 0.17, nor negative and neutral distractors (M = 181.49 ms, SD = 35.80 ms), t(14) = 1.38, p = 0.19. There was a significant difference between neutral distractors and T1, t(28) = 2.47, p = 0.02, corresponding to a 27 ms difference in onset. When we removed the three subjects who did not show an N2 during the time window, the onset of the N2 to the negative (M = 199.74 ms, SD = 19.89 ms) and neutral distractors (M = 194.48 ms, SD = 21.83 ms) further approached the onset of T1, and the significant difference between neutral distractors and T1 disappeared, t(25) = -1.62, p = 0.12 (all other comparisons remained non-significant). Thus, N2 amplitude and onset latency measures corroborate the behavioral findings and support the idea that EIB and AB rely on remarkably similar processes.
Chapter 4

DISCUSSION

The behavioral results for the EIB paradigm replicate the findings of Kennedy and Most (2015) in showing an absence of lag 1 sparing for negative distractors in the EIB paradigm. Importantly, a significant blink was also observed for neutral distractors and it was larger at lag 1 compared to lag 3, indicating an absence of lag 1 sparing in this condition as well. Finally, the AB paradigm also failed to show evidence of lag 1 sparing. These results indicate that the absence of lag 1 sparing is not a unique feature of emotional distractors and cannot be attributed to unusually rapid attention capture by emotional stimuli.

Prior evidence indicates that the occurrence of lag 1 sparing in AB depends on a variety of task and stimulus factors. In the present AB study, T1 and T2 involved a task switch (T1: determine the color of a tractor and T2: determine the orientation of a scene) and employed complex stimuli (scenes). Both of these factors are known to reduce the likelihood of lag 1 sparing, so perhaps it isn’t surprising that we found an absence of lag 1 sparing in the AB condition. The prediction of an absence of lag 1 sparing in the EIB condition is more uncertain. Like AB, the EIB condition used pictorial stimuli. However, it is difficult to know whether there is a task switch between the distractor and the following target because participants don’t have an explicit task for the distractor. Without this explicit task switch, the absence of lag 1 sparing reported here and in Kennedy and Most (2015) is unexpected and more surprising. It isn’t immediately obvious why lag 1 sparing does not occur in EIB.

One idea that may explain the pattern of EIB results found here is the notion that although participants are not actively searching for the task-irrelevant distractor
picture they may be actively attempting to ignore it (Cunningham, & Egeth, 2016). The perceptual set developed to ignore the distractor clearly differs from the set used for the target and may constitute a task switch and contribute to the observed absence of lag 1 sparing. In addition, as Allport and Hsieh (2001) point out, “task sets” aren’t always endogenously maintained but can be established in a “bottom-up” manner by stimuli or by an interaction between stimuli and endogenous sets. For example, the negative picture may capture attention automatically and establish a set consisting of looking for other distracting or emotional stimuli. This set needs to be suppressed and followed by a switch to the target task set (“look for a rotated picture”). A similar sequence of operations forms the basis of Di Lollo’s temporary loss of control (TLC) theory of the attentional blink (Di Lollo, Kawahara, Ghorashi & Enns, 2005).

Crucially, the neutral distractor condition controls for any differences in task-switching between the EIB and AB paradigms. The blink associated with neutral distractors is smaller than that associated with negative pictures, suggesting that emotional salience may add additional attention capturing properties to the physical salience possessed by both pictures. Importantly, though, the neutral distractor also results in a clear absence of lag 1 sparing showing that any additional effects the negative distractors have on target detection are not a necessary requirement to eliminate lag 1 sparing.

We also collected ERPs during EIB and AB in order to gather converging evidence on the related claim that emotional stimuli capture attention more rapidly than unemotional stimuli, perhaps contributing to their ability to suppress target information appearing at short delays (Kennedy and Most, 2015). We examined the onset latency of the N2 component (Grubert, Fahrenfort, Olivers, & Eimer, 2017) in
order to assess differences in the speed of attention capture across the two paradigms. We found that the onset latency of the N2 was similar in response to negative and neutral distractors in EIB and the T1 in AB. This is compatible with the claim that these stimuli capture attention at comparable latencies.

Overall, the evidence favors the conclusion that similar mechanisms are at work in both paradigms. The current results don’t support the claim that emotional stimuli capture attention using specialized mechanisms that act faster, or in different ways, than their non-emotional counterparts. Of course, they don’t rule out such a system either. It is possible that our negative stimuli did indeed activate a subcortical pathway involving the amygdala and that this activation played some role in their ability to capture attention during EIB. EEG is essentially blind to activity in the amygdala and therefore cannot be used to assess its level of activation or whether it is involved in EIB. However, if these specialized mechanisms do play a role in EIB, they appear to result in attention capture with similar latencies to those responsible for non-emotional capture.

The results from the current study allow us to add the absence of lag 1 sparing to the list of similarities between EIB and AB. So far, the emotional blink appears to be just an attentional blink in disguise.
REFERENCES


Appendix

IRB APPROVAL DOCUMENTS

RESEARCH OFFICE
210 Hullihen Hall University of Delaware
Newark, Delaware 19716-1551
Ph: 302/831-2136
Fax: 302/831-2828

DATE: March 8, 2018

TO: James Hoffman
FROM: University of Delaware IRB

STUDY TITLE: [1022783-2] Neural Mechanisms in the Attentional Blink
SUBMISSION TYPE: Continuing Review/Progress Report
ACTION: APPROVED
APPROVAL DATE: March 8, 2018
EXPIRATION DATE: March 20, 2019
REVIEW TYPE: Expedited Review
REVIEW CATEGORY: Expedited review category # (4,7)

Thank you for your submission of Continuing Review/Progress Report materials for this research study. The University of Delaware IRB has APPROVED your submission. This approval is based on an appropriate risk/benefit ratio and a study design wherein the risks have been minimized. All research must be conducted in accordance with this approved submission.

This submission has received Expedited Review based on the applicable federal regulation.

Please remember that informed consent is a process beginning with a description of the study and insurance of participant understanding followed by a signed consent form. Informed consent must continue throughout the study via a dialogue between the researcher and research participant. Federal regulations require each participant receive a copy of the signed consent document.

Please note that any revision to previously approved materials must be approved by this office prior to initiation. Please use the appropriate revision forms for this procedure.

All SERIOUS and UNEXPECTED adverse events must be reported to this office. Please use the appropriate adverse event forms for this procedure. All sponsor reporting requirements should also be followed.
Please report all NON-COMPLIANCE issues or COMPLAINTS regarding this study to this office. Please note that all research records must be retained for a minimum of three years.

Based on the risks, this project requires Continuing Review by this office on an annual basis. Please use the appropriate renewal forms for this procedure.

If you have any questions, please contact Nicole Farnese-McFarlane at (302) 831-1119 or nicolefm@udel.edu. Please include your study title and reference number in all correspondence with this office.
DATE: May 7, 2019

TO: James Hoffman, PhD
FROM: University of Delaware IRB

STUDY TITLE: [911177-7] Rapid Perceptual suppression in Emotion Induced Blindness

SUBMISSION TYPE: Amendment/Modification

ACTION: APPROVED

APPROVAL DATE: May 7, 2019

EXPIRATION DATE: June 7, 2019

REVIEW TYPE: Expedited Review

REVIEW CATEGORY: Expedited review category # (4,7)
Thank you for your Amendment/Modification submission to the University of Delaware Institutional Review Board (UD IRB). The UD IRB has reviewed and APPROVED the proposed research and submitted documents via Expedited Review in compliance with the pertinent federal regulations.

As the Principal Investigator for this study, you are responsible for and agree that:

- All research must be conducted in accordance with the protocol and all other study forms as approved in this submission. Any revisions to the approved study procedures or documents must be reviewed and approved by the IRB prior to their implementation. Please use the UD amendment form to request the review of any changes to approved study procedures or documents.
- Informed consent is a process that must allow prospective participants sufficient opportunity to discuss and consider whether to participate. IRB-approved and stamped consent documents must be used when enrolling participants and a written copy shall be given to the person signing the informed consent form.
- Unanticipated problems, serious adverse events involving risk to participants, and all non-compliance issues must be reported to this office in a timely fashion according with the UD requirements for reportable events. All sponsor reporting requirements must also be followed.

Oversight of this study by the UD IRB REQUIRES the submission of a CONTINUING REVIEW seeking the renewal of this IRB approval, which will expire
on June 7, 2019. A continuing review/progress report form and up-to-date copies of the protocol form and all other approved study materials must be submitted to the UD IRB at least 45 days prior to the expiration date to allow for the required IRB review of that report.

If you have any questions, please contact the UD IRB Office at (302) 831-2137 or via email at hsrb-research@udel.edu. Please include the study title and reference number in all correspondence with this office.