UNIVERSITY OF PADOVA

Department of General Psychology

Master's Degree in Cognitive Neuroscience and Clinical Neuropsychology

Final Dissertation

The relationship between excessive Instagram use and the emotional attentional blink elicited with positive affective and Instagram-related stimuli – an ERP study

Supervisor
Dr. Tania Moretta

Candidate: **Richard Morris III**
Student ID number: **2071335**

Academic Year 2023/2024

Abstract

Background and Aims

Theoretical arguments and empirical evidence suggest that problematic use of social media (PUSM) is characterized by sensitized cue reactivity. However, no study to date has investigated cue reactivity in PUSM when the social-media-related cues are task-irrelevant. The present study aims to examine cue reactivity to social-media (i.e., Instagram)-related visual stimuli across varying levels of problematic Instagram use severity.

Methods

90 participants of varying nationalities completed an emotional attentional blink (EAB) task with neutral, pleasant, and Instagram-related images. For a subset of participants, event-related potentials (ERPs) were recorded during the EAB task. Self-report measures for the degree of problematic Instagram use, motives for Instagram use, depression, anxiety, and stress were collected using scales validated in English and Italian.

Results

Higher problematic Instagram use was not correlated to lower response accuracy in the task for pleasant and Instagram-related stimuli compared to neutral stimuli. Behavioral and electrophysiological data supported the notion that the EAB had a different shape in the Instagram condition compared to the pleasant and neutral conditions. Pleasant and Instagram-related stimuli elicited larger ERP negativity (150 – 300 ms) compared to neutral stimuli, and pleasant stimuli elicited larger ERP positivity (400 – 600 ms). Only ERP positivity correlated to response accuracy in the behavioral task.

Discussion

Instagram-related stimuli are able to capture attention in a task for which their presentation is task-irrelevant, regardless of the level of problematic Instagram use. Pleasant and Instagram-related stimuli may be more difficult to disengage from than neutral stimuli, and although it may not be category-specific, problematic Instagram use may predict lower response accuracy in general in dynamic attention tasks.

Keywords: cue reactivity, event-related potentials, Instagram, emotional attentional blink

Table of Contents

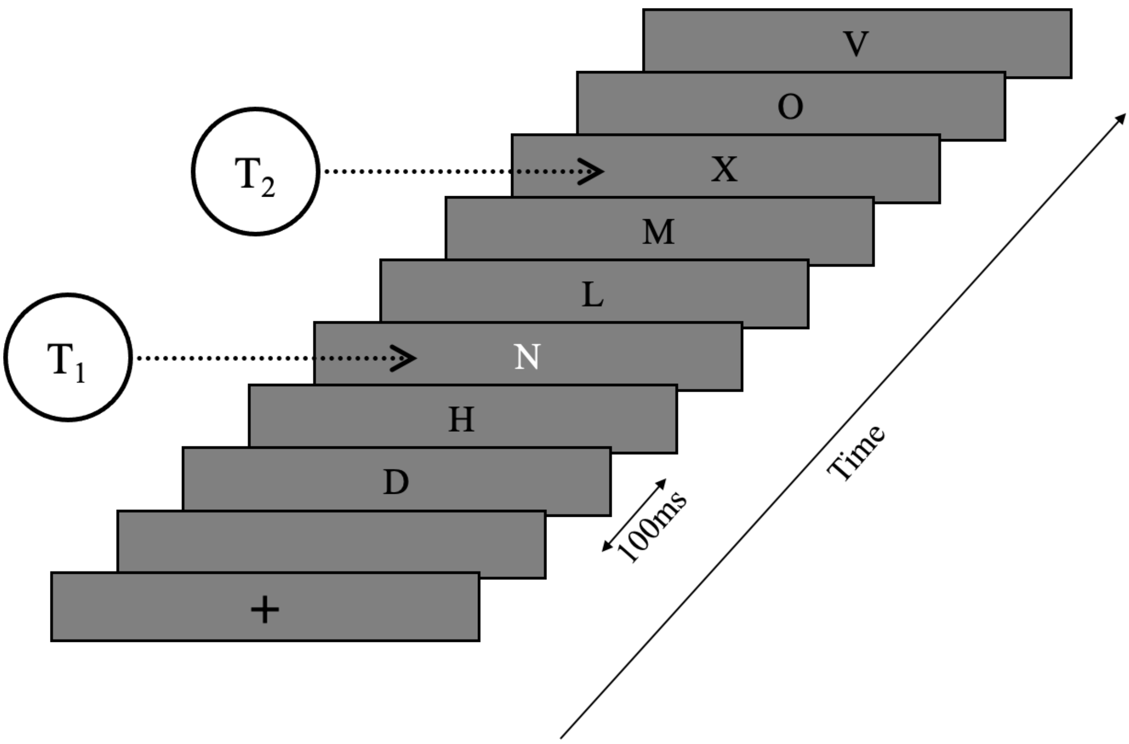
Chapter 1: The Attentional Blink and Emotional Attentional Blink Paradigms

The attentional blink and emotional attentional blink are important phenomena in the field of attention and psychophysics. Recent work has shown that these two effects show promise as indexes of change in psychiatric and psychological conditions, bringing them into the field of clinical psychology as possible tools of investigation and progress measurement. While the two effects are similar, the characteristics of one may not predict the characteristics of the other within an individual, but both inter- and intraindividual differences in regard to these two phenomena may shape future research in psychophysics, cognitive neuroscience, psychophysiology, and clinical psychology. To effectively utilize these effects, it is important to understand their relation to one another and the areas of their understanding that still lack clarity.

1.1 Definition of the Attentional Blink

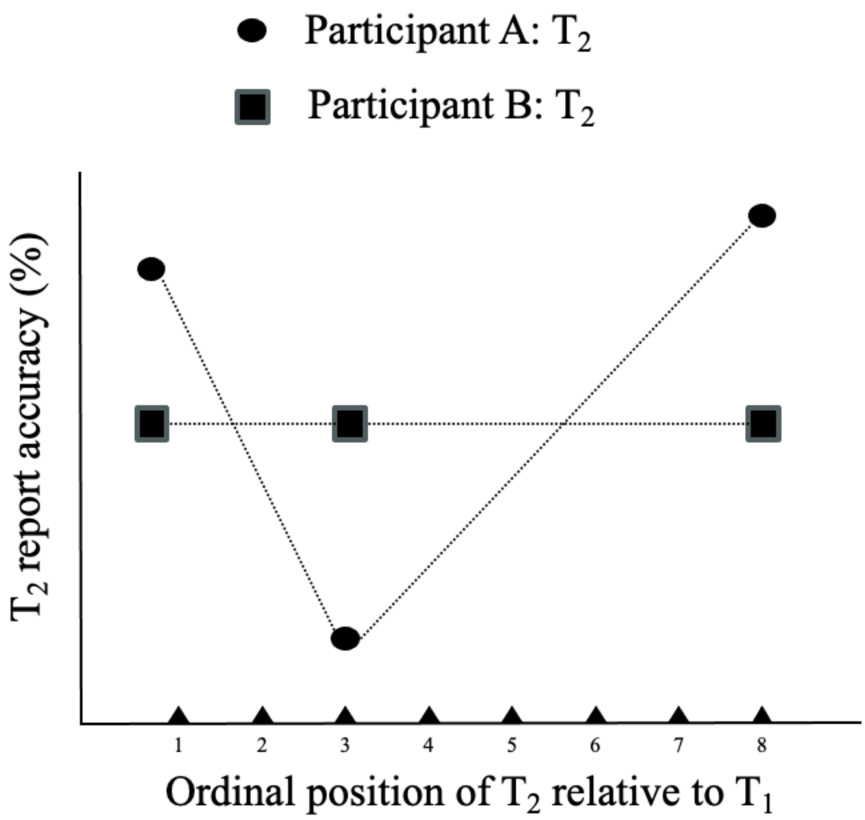
When two target stimuli (T1 and T2) are presented within approximately 500 ms of one another during a rapid serial visual presentation (RSVP) stream, there is an impairment in T2 report accuracy compared to when the two targets are presented with greater latency relative to one another. This phenomenon is termed the attentional blink (AB). The AB is reliably elicited in the context of an RSVP stream when T2 is followed by a distractor, and the viewer attempts to actively attend to both T1 and T2. This paradigm necessarily depends on goal-driven attention in that it requires top-down control of attention in order to perform the subsequent report of the targets (Dux & Marois, 2009; MacLean & Arnell, 2012; Martens & Wyble, 2010; Raymond et al., 1992).

Figure 1. Example of a classic AB paradigm in which T1 is a white letter, T2 is the letter X, and distractors are black letters other than X. Participants must report the identity of the white letter and the subsequent presence or absence of the letter X; therefore, both T1 and T2 must be attended to.



Many researchers employ the AB as an index of attentional limitations; however, to appropriately use the AB in this manner, it is fundamental to understand the difference between the criteria that define the AB effect and those that define the modulation of this effect. The magnitude of the AB can be mathematically represented by a function describing how the temporal lag between T1 and T2 affects the accurate detection of T2. As with other cognitive measures, the important observation is a change in performance as a function of a change in a continuous variable—time, in the case of the AB.

Figure 2. AB magnitudes cannot be compared using overall T2 report accuracy.



In an RSVP stream, the serial positions following T1 are called lags, so lag 3 would correspond to the third stimulus presented after T1, for example. Graphically, the accuracy of the T2 report can vary as a function of the number of distractors between T1 and T2, but the lag-dependent T2 accuracy function is not interchangeable with the height of the function, which would represent the mean T2 performance across lags. MacLean and Arnell (2012) assert that estimating the AB by using the overall T2 accuracy confounds overall T2 performance ability with the crucial aspect of the function of interest—the effect of the increasing temporal lag between T1 and T2 on performance—which evidence suggests are dissociable (Arnell et al., 2006; Arnell et al., 2010; Colzato et al., 2007). To illustrate the concept, they make the example that if Participant A has 20% T2 accuracy at lag 3 and 80% T2 accuracy at lag 8, they have 50% T2 accuracy overall and a very large lag-dependent difference in T2 accuracy (60 %, if the AB is measured as a simple subtraction of lag 8 – lag

3 T2 accuracy). If Participant B has 50% T2 accuracy at lag 3 and 50% T2 accuracy at lag 8, then they too have 50% T2 accuracy overall, yet there is no lag-dependent T2 accuracy impairment that reflects the AB. In this instance, a measure that represents the slope of the function would accurately demonstrate that the two participants have different AB magnitudes, but using overall T2 accuracy would incorrectly suggest equivalent ABs.

1.2 History of the Attentional Blink

In 1987, Broadbent and Broadbent designed an experiment in which subjects were presented with an RSVP stream of words with two targets defined either by word category or case. The researchers noticed that the report of the second target was impaired when this target was presented within half a second of the first. In the same year, Weichselgartner and Sperling found a similar result. In their study, subjects were tasked with reporting a target and the three distractors following the target. Subjects instead reported the target, the distractor immediately following the target, and then the distractor 400 ms after the target. Both Broadbent and Broadbent (1987) and Weichselgartner and Sperling (1987) proposed that this effect was due to a sensory processing limitation, and logically neither called the phenomenon an attentional blink.

It was Raymond et al. (1992) who coined the term attentional blink and demonstrated that the target processing deficit was an attentional limitation rather than a sensory one as Broadbent and Broadbent (1987) and Weichselgartner and Sperling (1987) had hypothesized (Dux & Marois, 2009). In the first task deployed specifically to investigate the phenomenon, T1 was a white letter with black letter distractors and T2 was the letter X appearing at one of eight possible lags. Participants that were asked to ignore the white letter and only report the presence or absence of the X had a statistically higher rate of correct detection than those asked to report both the white letter and the X. The strong reduction in this T2 reporting deficit when instructed to ignore T1 demonstrated that the effect was due to an attentional limitation and not a perceptual one since the same visual stimuli yielded different effects depending on task requirements.

Raymond et al. (1992) also observed that in the dual task condition, in which both T1 and T2 must be attended, the accurate detection of the X was impaired at lags 2 – 5, which corresponded to stimulus onset asynchronies of 180 – 450 ms after the presentation of the white letter. The same experiment also demonstrated that when T2 directly followed T1 100 ms later, there was essentially no deficit in T2 reporting, which we now term lag-1 sparing and was also evident in Weichselgartner and Sperling (1987)'s results. Moreover, T2 detection was not impaired in the lags corresponding to 520 – 720 ms after T1 presentation, and this return to normal T2 detection was evidence that the post-target detection impairment was temporary, thus characterizing the approximate durational limits of the AB. Taken together, these seminal studies at the end of the twentieth century allow researchers to assert that the primary criterion for identifying the presence of an AB is evidence of a lag-dependent effect on T2 detection in which detection is impaired when target separations are within approximately 500 ms (MacLean & Arnell 2012).

1.3 Mechanisms of the Attentional Blink

The AB has been largely employed throughout the field of attentional research because it is informative about the rate at which stimuli are encoded into consciously accessible representations. Following the seminal experiments in the late twentieth century marking the discovery and establishment of the phenomenon in the scientific community (see Broadbent & Broadbent, 1987; Raymond et al., 1992; Weichselgartner & Sperling, 1987), many studies investigated at what processing stage and in what way a blinked target is "lost". A review by Martens and Wyble (2010) notes that convergent evidence from both behavioral

(Maki et al., 1997; Martens et al., 2002; Potter et al., 2005; Shapiro et al., 1997a,b; Visser et al., 2005) and neuroimaging studies (Luck et al., 1996; Marois et al., 2004; Pesciarelli et al., 2007; Rolke et al., 2001; Sergent et al., 2005) revealed relatively quickly after the initial discovery of the AB that even unreported targets are processed to a late stage in the processing pathway. Blinked words can facilitate the processing of subsequently presented words if they are semantically related to the blinked word (Martens et al., 2002; Shapiro et al., 1997a). Blinked words also induce electrophysiological activity associated with semantic processing (Luck et al., 1996), which, taken together with behavioral data, indicates that the blinked word is only “lost” in the sense that it is not consciously accessible for report.

Psychophysiological findings suggest that the AB is related to stimulus selection processes in the posterior parts of the brain housing anatomical structures utilized early on in the visual processing hierarchy (for a review, see Martens & Wyble, 2010). EEG studies have also revealed an association between the AB and a reduced N2, which occurs after the perceptual event-related potential (ERP) components that remain relatively unaltered during the AB such as the N1 and P1. The timing of the altered N2 relative to the perceptual ERPs suggests that the AB is mediated by feedback mechanisms triggered by processing in higher-level brain areas that project back to earlier areas (Sergent et al., 2005, Dell’Acqua et al., 2006. Jolicœur et al., 2006a, Jolicœur et al., 2006b, Martens & Wyble, 2010). These studies also support the most widely referenced explanation of the AB in attentional literature, which states that the processing of T1 requires the creation of a high-level representation that must then be consolidated into working memory. The consolidation process in turn creates a short-lived central bottleneck that temporarily stops the same consolidation process from occurring for T2, so if T2 is masked by a distractor, the preconscious representation of T2 is overwritten by the new information of the distractor (Chun & Potter, 1995; Jolicœur & Dell'Acqua, 1998, 1999, Ching & Davis, 2021). Essentially, T1 processing renders attentional resources temporarily unavailable for new information and impairs the report accuracy of T2 at short lags. However, there are a number of other theories that attempt to describe the AB and lag-1 sparing effect with varying levels of success[1].

At this time, no one theory can fully account for all the findings related to the AB. However, regardless of the specifics of the myriad of theories describing the AB, it is a robust phenomenon that has been reliably demonstrated across an extensive range of experimental conditions, and the literature strongly suggests that the AB reflects the competition between targets for attentional resources for working memory encoding, episodic registration, response selection, distractor inhibition, and target representation enhancement (Dux & Marois, 2009).

1.4 Event-Related Potentials Associated with the Attentional Blink

Event-related potentials (ERPs) provide a voltage measurement of neural activity that is recorded noninvasively from electrodes placed on multiple scalp regions. These voltage measurements reflect the summation of postsynaptic potentials constituting neural activity and are passively conducted through the skull to the scalp where they can be read as outputs of the electroencephalogram (EEG). ERPs are normally small compared to larger background EEG activity, so multiple stimulus presentations are necessary to calculate the average stimulus-locked signal in order to extract the ERP of interest. Brain activity associated in some way with the processing of the stimulus becomes visible as positive and negative deflections in the output waveform. In sum, an ERP is the result of averaging the EEG signal

---

[1] In a review by Dux and Marois (2009), the authors note that each theory predicts that at least one or more of the following processes leads to the AB: Perceptual inhibition of post-T1 stimuli due to the potential for T1 and T1+1 featural confusion (gating theory); Sustained post-perceptual suppression triggered by the T1+1 distractor (boost and bounce theory); Online T1 attentional depletion due to T1 working memory encoding/episodic registration/response selection (bottleneck theories, hybrid models, global workspace model, gated auto-associator model, CODAM, LCNE, attention cascade theory, eSTST; Competition between target and distractor stimuli during offline retrieval from working memory (interference theory); Disruption of an input filter by the T1+1 distractor (TLC, Kawahara et al.'s (2006) hybrid model); Suppressed/delayed attentional enhancement of T2 (delayed attentional engagement, LCNE, CODAM, attention cascade theory, eSTST, threaded cognition model).

from many trials that have been time-locked to a specific stimulus in order to reveal the components of the waveform associated with the cognitive process of interest.

By contrasting trails with either a short or long lag, researchers utilizing EEG have been able to pinpoint the moment that brain activity time-locked to T2 presentation shows evidence of the AB occurring (Sergent et al., 2005; Dell'Acqua et al., 2006; Jolicœur et al., 2006a; Jolicœur et al., 2006b). One of the earliest ERPs implicated in the AB effect is the N2 component, which is associated with the allocation of attention to a target and thought to index a stage responsible for selecting a relevant object among distractors (Kennedy et al., 2014; Woodman, Arita, & Luck, 2009; Luck & Hillyard, 1994). It is normally evoked in parietal and occipital areas around 200 ms after target onset and is evoked by T2 on trials with a long lag. The N2 for T2 is substantially suppressed in trials with a short lag, which is when the AB is likely to occur. However, if the T1 is successfully ignored, the N2 is still induced by the T2 (Sergent et al., 2005; see also Dell'Acqua et al., 2006; Jolicœur et al., 2006a; Jolicœur et al., 2006b in regard to the N2pc).

Psychophysiological evidence has also revealed differences in parietal regions between "blinkers" (those in which an AB can be reliably elicited) and "non-blinkers" (individuals constituting about 5% of the population in which the AB is strongly reduced or absent entirely), which has led to a greater understanding of the importance of the P3 component in AB research. Blinkers and non-blinkers exhibit a difference in latencies of the P3 component induced by T2 targets successfully identified, which suggests that non-blinkers are likely faster at consolidating the identity of targets than blinkers are (Martens et al., 2006). The P3 in non-blinkers appears at a shorter latency following the T2 presentation compared to that of blinkers.

An increased amplitude of the P3 component is associated with the cognitive processing of task-related or unexpected stimuli and is thought to index the consolidation of an object in working memory (Donchin, 1981; Polich, 2003, 2007; Vogel & Luck, 2002). In the AB paradigm, the P3 time locked to T2 presentation is attenuated at short lags compared to long lags, which is consistent with the inability to accurately report T2 (Harris et al., 2013; Vogel et al., 1998). When T2 is the last item in the RSVP stream and is therefore not followed by any distractors, there is an increase in the latency of the P3 component but no attenuation, suggesting delayed but successful T2 detection (Ching et al., 2021; Arnell, 2006; Ptito et al., 2008). The relative lack of modulation in earlier perceptual components further suggests that during the AB there is a delay in later P3-associated processes such as stimulus categorization (Picton, 1992) and working memory (Akyürek et al., 2010).

1.5 Possible Modulations of Attentional Blink

According to many theories, the AB depends on the duration of the central processing of T1 (Jolicœur & Dell'Acqua, 1999), the similarity between targets and distractors (Chun & Potter, 1995), the presence or absence of a mask following the first (Seiffert & DiLollo, 1997) or second target, and the response idiosyncrasies of the subject (Giesbrecht & DiLollo, 1998). Different groups may show varying degrees of AB magnitude and duration, and these differences are a promising area of study because they lend themselves well to the investigation of both the underlying causes of the AB and the root of the group differences in question. Examples of past work include research examining the elderly (Lahar et al., 2001) and bilinguals (Colzato et al., 2008), which show stronger and/or longer AB compared to the young and monolinguals, respectively. Contrastingly, action video-gamers (Green & Bavelier, 2003), expert mediators (Slagter et al., 2007), and non-blinkers show either a reduced or entirely absent AB compared to control groups. Furthermore, targets of motivational value or especially salient targets in the T2 condition can “break through” the refractory period of the AB (Keil & Ihssen, 2004; Anderson, 2005; Milders et al., 2006). For instance, an RSVP stream with a specific addiction-related stimulus presented as T2 elicits a reduced AB in individuals afflicted with the associated behavioral or substance addiction (Tibboel et al., 2010; Brevers et al., 2011; Liu et al., 2008). This kind of modulation also extends to emotions (Mathewson et al., 2008). Notably, emotionally-arousing words presented as T2 are less susceptible to the AB than non-arousing T2 words (Keil & Ihssen, 2004), and emotionally-arousing T2 words are more susceptible to the AB when preceded by an emotionally-arousing T1 word (Schwabe & Wolf, 2010; Schwabe et al., 2011).

1.6 Definition of the Emotional Attentional Blink

The emotional attention blink (EAB), also called emotion-induced blindness, is a phenomenon that is comparable to, but inarguably different from, the AB. The EAB, like the AB, can be elicited in the context of an RSVP stream in which the primary target is preceded temporally by a task-irrelevant, emotionally-arousing stimulus. To contextualize in terms of the AB, the emotional stimulus is effectively T1, but T2 is the sole target. When the emotional stimulus is sufficiently arousing and physically distinctive from other distractors, report accuracy of the target is impaired compared to conditions in which the emotional stimulus is absent (Mathewson et al., 2008; MacLeod et al., 2017; McHugo et al., 2013; Singh & Sunny, 2022; Wang et al., 2012). Recent investigations demonstrate that the reduction of the target report accuracy during an EAB is smaller than the reduction in T2 report accuracy during an AB, suggesting that the EAB has a weaker effect than the AB (Santacroce et al., 2023).

The optimal conditions for the elicitation of an EAB are those in which the emotional distractor must be semantically processed and is physically distinct from other distractors in the RSVP stream (Santacroce et al., 2023). However, the effect is still reliably elicited when these conditions are not met and is well established in the attentional literature. In fact, even taboo words presented as to-be-ignored distractors among a series of neutral words are able to elicit an EAB regardless of the lack of physical distinctiveness between the neutral words and taboo distractors (Mathewson et al., 2008). Interestingly, it is unclear whether lag-1 sparing can be found in the EAB paradigm, and it is often absent in EAB studies (Kennedy & Most, 2015b; MacLeod et al., 2017).

While the AB is dependent on goal-driven attentional control, the EAB is contrastingly dependent on stimulus-driven attentional control. Moreover, more arousing emotional stimuli lead to greater impairment in the EAB paradigm when valence is controlled for (Singh & Sunny 2017). Both positive and negative emotional stimuli may lead to a statistically significant impairment in target detection in high arousal conditions (Most et al., 2007; Singh & Sunny 2017). Importantly, the EAB can be repeatedly elicited since exposure to and expectation of highly arousing emotional distractors does not eliminate their ability to capture attention (Arnell et al., 2007).

1.7 History of the Emotional Attentional Blink

As a natural extension of the AB paradigm, researchers in the early 2000s found that presenting emotional distractors, even as to-be-ignored distractors, could result in what appeared to be an AB (Arnell et al., 2004; Most et al., 2005). It was Most et al. (2005) who provided an initial description of the EAB and coined the, now slightly less favored, term emotion-induced blindness. In the original experiment, participants searched for a single rotated image of a landscape or building presented in an RSVP stream full of upright landscape or architectural photos. Either 200 ms or 800 ms prior to the target image, a distractor of either an affectively negative, neutral, or scrambled image appeared. Target accuracy was most impaired at the short lag of 200 ms compared to the 800 ms lag time following negative affective distractors.

Further examination of the time course of the EAB revealed that the effect can be demonstrated as early as lag 1 and declines substantially after lag 2 (Most & Junge, 2008).

1.8 Mechanisms of the Emotional Attentional Blink

Briefly presented affective images can be selectively processed in a similarly to how longer image presentations are processed (Schupp et al., 2004a). In EEG studies, both pleasant and unpleasant briefly-presented images are associated with early endogenous negative shifts over temporo-occipital sensors and enlarged late positive potentials over centro-parietal sensors relative to neutral image presentations (Schupp et al., 2004a). Other results of ERP studies exploring the cortical processing of affective stimuli are consistent with the hypothesis that affective images draw attentional resources and further suggest that both brief and prolonged presentations of affectively-salient images are sufficient for selective perceptual processing of the image (Cuthbert et al., 2000; Schupp et al., 2003a; Lang et al., 1997; Schupp et al., 2004a).

One theory underlying the ability and potential benefit of the selective processing of emotional cues, even when briefly presented, is that the rapid and reliable detection of positive and negative reinforcers facilitates adaptive behavior to promote survival and reproductive success (Cacioppo et al., 1999; Lang et al., 1997; Öhman et al., 2000; Schupp et al., 2004a). According to this hypothesis, it would be evolutionarily advantageous to be able to reliably detect potentially relevant emotional cues with even just a glimpse, and cues with the highest emotional intensity would be easiest to selectively process. This theory is partially supported by the finding that both early and late selective ERP modulations are most pronounced for images prompting the highest affective engagement (Schupp et al., 2004a).

However, studies comparing the relative strength of the AB and EAB reveal that even when a task-irrelevant emotional distractor captures attention, the magnitude of the resulting blink is small compared to the goal-driven AB (Santacroce et al., 2023). The smaller relative magnitude of the EAB suggests that in rapidly changing settings, salient task-irrelevant stimuli are unlikely to take priority over the current goal and is evidence against the idea that attentional capture by irrelevant stimuli serves as an alerting signal to override goal-driven attention when there is danger in the environment. This finding is not entirely surprising given that attentional capture by task-irrelevant stimuli is rapidly attenuated under conditions of high attentional demands (Asplund et al., 2010; Stilwell et al., 2019).

In studying the mechanisms driving the EAB, researchers naturally first informed their assumptions based on knowledge of the AB, but the mechanisms of the EAB and how they relate to those of the AB are still unclear. Research has provided evidence for many differences between the AB and EAB effects (McHugo et al., 2013; Singh & Sunny, 2022; Wang et al., 2012), but it has also produced results to suggest similar mechanisms underlying the two phenomena (MacLeod et al., 2017; Mathewson et al., 2008). Regardless of the distinct or shared mechanisms, even by those researching the differences between the two effects, the EAB is discussed as a "blink" driven by emotional capture that is comparable to the classic goal-driven AB (Santacroce et al., 2023; MacLeod et al., 2017; McHugo et al., 2013; Olatunji et al., 2022).

As a point of divergence between the two phenomena, Wang and Most (2011) noted that impairments of T2 report accuracy elicited by neutral color and landscape stimuli were not spatially localized, but impairments caused by emotional images were confined to the distractors' location. The researchers assert that the spatially localized nature of the impairment only emerges in the temporal wake of emotional distractors, suggesting the EAB does not stem solely from the tendency of attention to spontaneously orient to emotional stimuli but includes a spatial component not necessarily present in the AB. These results form, in part, the spatiotemporal competition theory, which postulates that if emotional distractors evoke an EAB by competing with the target for early-stage perceptual resources, the distractors should interfere with target processing when the emotional distractor and target are presented in the same location (Wang et al., 2012). However, if the emotional distractor causes the EAB even when the target is in a different spatial location, the EAB likely occurs at a later central processing bottleneck similar or possibly identical to that of the AB (Wang et al., 2012). Wang et al. (2012) found that emotional distractors produced an EAB only when presented in the same spatial location as the target, suggesting that EAB may not depend on a central bottleneck but occurs at an early, spatial processing level. Spatial selection is impaired during the AB but appears to be intact during the EAB (Jiang & Chun, 2001).

Some studies amend Wang and Most (2011)'s assertion that the EAB does not solely rely on emotional salience by adding that physical distinctiveness between distractors may be required to allow stimulus-driven attentional capture in an RSVP stream (Santacroce et al., 2023; Hoffman et al., 2020). Santacroce and her colleagues (2023) found no EAB when emotional distractors where not physically distinct even when target selection required semantic processing of all stimuli in the RSVP stream by defining the target on the criteria of image content. These results suggest that the production of an EAB relies on distractors that capture attention for non-emotional reasons that are then difficult to disengage from due to emotional salience.

Reliance on physical distinctiveness could also explain the results of studies in which blinks were observed in the neutral condition (Huang et al., 2008; Kennedy & Most, 2015a; Santacroce et al., 2023; Onie & Most, 2021). In these cases, the neutral distractor is typically of a category that is physically distinct from the other distractors. For example, neutral items are normally images of humans or animals while the other distractors may be of objects or landscapes. Santacroce and her colleagues (2023) posit that the initiation of the stimulus-driven attentional capture underlying the EAB is driven by the distinctiveness of the emotional distractor from filler items and the emotional salience intensifies or prolongs the capture, thus implying difficulty with disengagement from emotional stimuli in a dynamically changing environment such as an RSVP stream.

1.9 Event-Related Potentials Associated with the Emotional Attentional Blink

The similarity of the behavioral results between the AB and EAB suggests that the two effects may share similar underlying mechanisms, though likely not identical ones. As with the AB, an EAB elicited by highly emotionally-arousing words is associated with an increased early posterior negative component hypothesized to represent early semantic activation and selection for further processing in working memory, which has been suggested by some to simply be the N2 component (Schupp et al., 2003a, 2003b; MacLeod et al., 2017). The same is true of a modulated P3 component, which is a common characteristic of both phenomena (MacLeod et al., 2017). The amplitude of the N2 and P3 components are both enlarged following emotionally-arousing words presented in an RSVP stream, and these amplitudes are predictive of memory of the emotional words presented and poorer target accuracy at short lags compared to long lags (MacLeod et al., 2017). Moreover, it is unlikely that these ERP modulations reflect any sort of categorization of the image valence (Junghöfer et al. 2001, Schupp et al., 2003b, Schupp et al., 2003c) and instead most likely reflect a default mechanism that occurs even while subjects pursue other explicit cognitive goals.

1.10 Possible Modulations of the Emotional Attentional Blink

The EAB can be modulated along the same dimensions as the AB—magnitude and duration—and shows promise as a possible index of emotional cognitive processing and motivation. In one study, the effect was examined under conditions of reward and punishment. In this case, emotional human faces were used as the distractor of interest with either the emotion or the gender of the emotional face associated with a reward if T2 was correctly identified or a punishment if T2 was incorrectly identified (Gutiérrez-Cobo et al., 2019). Under these conditions, emotional faces produced an EAB when associated with a reward, and angry faces impaired T2 identification compared to the neutral face condition even when the face emotion was irrelevant to the current task (Gutiérrez-Cobo et al., 2019). These findings lend support to the hypothesis that the rapid processing of facial emotion may arise partly from automatic cognitive-perceptual processes. In both an AB and EAB paradigm, overall T2 accuracy was lower on trials with a valued distractor than with a non-valued distractor at short lags, suggesting valued stimuli receive more attentional resources and interfere with the process of subsequent target processing (Gutiérrez-Cobo et al., 2019). This finding is crucial for further research because it allows researchers to gauge which stimuli may hold value for subjects of particular populations in a quantifiable manner.

There is evidence indicating that the EAB can be used to detect altered sensitivity to disorder-relevant stimuli in psychiatric conditions such as obsessive-compulsive disorder (Olatunji et al., 2011b), generalized anxiety disorder (Olatunji et al., 2011a), and post-traumatic stress disorder (Olatunji et al., 2012). Thus, there may be great utility in the EAB as a measure of attentional biases toward concern-relevant stimuli in psychopathology.

The effect of the motivational state of participants on the EAB has also been studied in relation to natural rewards. Food stimuli may induce a larger EAB in fasting subjects compared to those not fasting, which demonstrates the potential for the EAB as a measure of dynamic changes in stimulus valuation (Piech et al., 2010). However, this finding directly contrasts with Neal and colleagues' (2023) study in which food cues did not result in an enlarged EAB in fasting individuals. It is possible that in Neal and colleagues' experiment, in which participants in the non-fasting condition were instructed to eat lunch one hour before performing the task, attentional resources may have been reduced due to a "midday slump". There is evidence to support the hypothesis that the ability to maintain attention and react quickly to the appearance of a new stimulus is impaired following the consumption of a meal (Smith et al., 1986). It is possible that in Neal and colleagues' study, it is not that fasting individuals performed the same as if they were not fasting, but instead that recently satiated individuals performed as poorly as when they were fasting. More research is necessary to clarify the effects of hunger on the EAB. Regardless, this hypothesized sensitivity to stimulus value would indicate that the EAB can also be a relatively objective marker of the effects of therapeutic interventions for conditions in which stimulus-reinforcer associations drive behavior.

The EAB may also be sensitive to more abstract sentiments such as patriotism or pride. One EAB study in Spain involving flags with different, sometimes controversial, connotations to participants—the flag of Cataluña, for example—revealed a larger EAB for stimuli representing Catalan and Spanish patriotism for participants who scored higher in patriotism compared to those who scored lower (Anzar-Casanova et al., 2020). Patriotism predicted the strength of the EAB in this study, serving as another example of how the EAB can be utilized as a psychological index of stimuli salience.

1.11 Chapter Summary

The AB can be utilized to reveal the temporal limits of goal-driven attention because the second of two proximate targets presented in an RSVP stream is often consciously inaccessible for report, and modulating the temporal relation between the two targets facilitates mental chronometry. The AB is sensitive to stimulus salience and may be modulated along several dimensions, which may prove to be a promising index of stimulus salience (Cousineau et al., 2006; Keil & Ihssen, 2004; Anderson, 2005; Milders et al., 2006).

The phenomenon's underlying mechanisms are still debated but are likely rooted in later cognitive processing stages rather than in early perceptual stages (Dux & Marois, 2009; Raymond et al., 2009).

The EAB describes the effect evoked when an emotionally arousing, task-irrelevant distractor is presented prior to a target item in an RSVP stream in which the subject is unable to accurately report the target. The emotionality of a stimulus influences the attentional prioritization of that stimulus, and so the EAB likely reflects bottom-up, involuntary attentional capture (Anderson, 2005; Kennedy & Most, 2015a). The presumed attentional priority allocated to the emotional stimuli results in reduced perceptual and/or cognitive resources available for processing the subsequent target stimuli following a similar time course to the AB (Kennedy & Most, 2015b). The EAB also shows promise as an index of the salience of stimuli because the size of the effect likely depends largely on the personal and dynamic valuation of the emotional stimuli (Olatunji et al., 2011a-b; Olatunji et al., 2012; Olatunji et al., 2022).

Both the preferential detection of emotional T2 stimuli in an AB paradigm and the attentional capture by emotional stimuli in the EAB paradigm reflect the prioritized processing of emotional stimuli. However, in the AB paradigm, the preferential detection of emotional T2 stimuli characterizes detection with limited attentional resources depleted due to T1 detection. Contrastingly, the EAB can be utilized to measure the impact of involuntary attentional capture on the processing of later stimuli. Although the two paradigms may not rely on the same mechanisms to measure attentional capture by stimuli either before or after a target, they can both be used to examine more completely the attentional modulations produced by the presentation of emotional and particularly salient stimuli.

Chapter 2: Attention, Emotion, and Problematic Use of Social Media

Seeking out positive and avoiding negative stimuli is a behavioral trait shared by most, if not all, organisms. This behavior facilitates adaptive decision-making that has likely shaped evolutionary processes due to its utility for survival (Volkow, 2019). However, in the era of social media, people are now presented with new kinds of social-media-related stimuli and rewards that may prompt maladaptive social-media-related decision-making and behaviors. Problematic use of social media (PUSM) has been characterized by excessive concern about the use of social media, impaired control over social media use, and spending so much time on social media that it has negative consequences in major areas of life functioning (Andreassen, 2015; Andreassen & Pallesen, 2014; Morris et al., 2023). While the debate about whether PUSM is an addiction remains open, research suggests that there are more similarities than differences between PUSM and addictive behaviors (Moretta & Buodo, 2021a,b; Gao et al., 2019; Antons et al., 2020; Weinstein & Lejoveux, 2010). One of the main components of many theories of addiction is the hypothesis that individuals afflicted with addiction have an increased cue reactivity to addiction-related stimuli (Brand et al., 2019; Robinson & Berridge, 1993, Moretta et al., 2022). There is strong evidence to support this hypothesis also in the context of PUSM. Individuals with PUSM show stronger cue reactivity to and possibly slower disengagement from social-media-related stimuli compared to neutral stimuli (Moretta & Buodo, 2021b; Gao et al., 2019).

Humans often respond to environmental cues because of their emotional and motivational significance, and this attentional capture of emotionally relevant stimuli is termed “motivated attention” (Lang et al., 1997; Öhman et al., 2000a; Schupp et al., 2006a). Importantly, behavioral and functional neuroimaging results suggest that the individuals with PUSM’s tendency to attend to and delay disengagement from social-media-related stimuli is strikingly similar to the nearly universal human tendency to attend to affective stimuli. One possibility for this is that in those with PUSM, social-media-related stimuli are more salient because they have gained an increased motivational significance through repeated exposure and present an increased demand for attentional resources.

The interaction between attention and emotion is well studied and is likely fundamental to the nascent field of PUSM research. Attentional resource allocation may be altered by the presence of emotional stimuli and, for those with PUSM, by the presence of social-media-related stimuli. Moreover, research suggests that there is also an interaction between PUSM and the cognitive response to affective stimuli (Moretta & Buodo, 2021a,b). Because of this interaction effect and the possible similarity in their underlying mechanisms, a review of the relationship between attention and emotion is essential for a comprehensive exploration of the possible cognitive modulations related to PUSM. This review also serves as a foundation used to ground the theoretical perspectives and methodological strategies taken to investigate how PUSM, attention, and emotion interact in the EAB paradigm.

2.1 Attentional Control States

The environments in which humans live are highly dynamic and rich with stimuli competing for attentional resources. Only a portion of the information in a given environment is made available for conscious access, can become the object of sustained attention, and can be subjected to controlled elaborative processing. Through the mechanisms of selective attention, certain information is prioritized for processing, and control of selective attention can be divided into an active and a passive form (Öhman et al., 2000a).

In active attention, the information that is prioritized for further cognitive processing is the result of predetermined perceptual or semantic criteria set by instruction, self-generated intention, or associative learning (Schupp et al., 2006a). The AB effect is dependent on active attention as it relies on goal-directed attentional capture. Conversely, the EAB is often viewed as being dependent on passive attention. In passive attention, the prioritized information reflects the capacity of stimulus features to capture attention. These features may include intensity, novelty, suddenness of onset, etc. (Schupp et al., 2006a). Schupp and colleagues (2006a) relate these forms of attentional control to memory by asserting that active attention effects reflect the expectancy of a certain stimulus and, therefore, the temporary activation of long-term memories. In contrast, passive attention effects reflect the failure to match current stimuli to the content of short-term memory store.

2.2 Approach and Withdrawal Systems

Several experts in the field of emotion agree that the affect system contains two motivational subsystems (Schneirla, 1959; Konorski, 1967; Dickinson & Dearing, 1979; Lang et al., 1990, 1997; Cacioppo et al., 1999). The approach system is implicated in activities accompanied by affectively pleasant states such as ingestion and copulation (Lang et al., 1990, 1997). The withdrawal system coordinates defense against and withdrawal from stimuli associated with affectively negative states such as nociceptive agents (Schupp et al., 2006a). Both of these subsystems can vary in terms of engagement depending on arousal level (Lang et al., 1990, 1997). Taken together, the postulates of the hypothesis that emotion is biphasic and consists partly of these subsystems suggests that emotions can be considered action dispositions preparing the organism to perform either an avoidance or approach behavior by interrupting ongoing actions and mental processes (Lang et al., 1990, 1997; Frijda, 1986; Schupp et al., 2006a).

The results of these emotional subsystems are not only observable in behavioral outcomes but in measures of autonomic, somatic, and reflex modulation reflecting the processing and evaluation of emotional stimuli (Bradley, 2000; Hamm et al., 2003; Lang et al., 1990). According to the view that emotions act as action dispositions, these modulations may also represent cognitive and physiological preparation of appropriate behavioral responses because these preparations require extraction and processing of information from the environment. Given that this information extraction is critical for behavior, it follows that emotional cues can direct attentional resources (Öhman et al., 2000b). Motivated attention may be strongly engaged by any highly arousing emotional stimulus regardless of its valence likely in part because of its utility for both approach and withdrawal behaviors (Junghöfer et al., 2001; Bradley et al, 2001).

2.3 Event-Related Potentials Associated with Processing of Emotional Stimuli

There are several ERP components associated with the differential processing of emotional visual stimuli compared to neutral visual stimuli. The earliest of these is a negative deflection across temporo-occipital electrode sites appearing around 150 – 300 ms after stimulus presentation called the early posterior negativity (EPN) in emotion literature. Due to the timing, scalp distribution, and eliciting conditions, many researchers assert that the EPN and N2 are the same component (MacLeod, 2017; Schupp et al., 2003a,b), and for the current project, I adopt this hypothesis and refer to the N2 and EPN component as the same. However, this is a strong assumption and a possible limitation to the project as a whole. The exact relationship between the N2 and the EPN is still somewhat unclear, and it is unknown whether the EPN is lateralized like the N2pc (Hoffman et al., 2020). Regardless of this lack of clarity, the hypothesis of their being the same component is not unfounded.

As noted in the previous chapter's examination of the N2 component, the EPN covaries with stimulus arousal levels but does not vary as a function of color, brightness, some measures of perceptual complexity, or spatial frequency (Junghöfer et al., 2001). However, the EPN may also be modulated as a function of image content (objects vs. people) and image type (single foreground item vs. scattered scenes and multiple items), which supports the hypothesis that the component is related to selecting an object among distractors for further processing (Bradley et al., 2007; Löw et al., 2005). The EPN is attenuated for objects compared to people and for scattered scenes with multiple items compared to clear foreground objects, and these results do not support the notion that the EPN solely reflects emotional arousal (Bradley et al., 2007; Löw et al., 2005). Some experimental results also suggest that attentional capture by physical salience instead of emotional salience can still evoke an EPN (Hoffman et al., 2020). Therefore, in experiments designed to investigate an effect dependent on emotional arousal by measuring the EPN, stimuli must be prudently selected in order to control for secondary explanations of ERP modulations due to image type or content.

Processing of emotional visual stimuli is also associated with increased late positive potentials (LPPs) over centro-parietal electrode sites with peaks between 400 – 600 ms after stimulus presentation, and this ERP is also often referred to as P3b (Palomba et al., 1997; Cuthbert et al., 2000; Schupp et al., 2000, 2003a, 2004a, b; Keil et al., 2002; Amrhein et al., 2004). This LPP component is more pronounced in response to more arousing stimuli regardless of valence or stimulus probability and is associated with the semantic meaning of task-relevant stimuli or the representation of stimuli in working memory (Schupp et al., 2004b; Johnson, 1988; Picton, 1992; Donchin & Coles, 1988). The LPP is also considered a sensitive measure of attention manipulations under the assumption of an attention-capacity-limited system. Two effects in particular support the claim of the LPP's sensitivity to attention manipulations. The first is that there is a strong association between instructions to attend to specified stimuli and the LPP amplitude associated with target detection (Donchin et al., 1986; Schupp et al., 2006a). The second is that in a dual-task paradigm, the LPP amplitude associated with the primary task is reciprocally related to the secondary task (Donchin et al., 1986).

One useful aspect of using these two ERPs as indices of emotional processing stages is that stimulus novelty is not a key feature in the elicitation of these components. The repeated presentation of emotional stimuli often prompts habituation across response systems as measured by skin conductance, heart rate, and corrugator muscle activity (Öhman et al., 2000a). In terms of motor output responses, the startle reflex is the only commonly used psychophysiological index in emotion research that does not habituate to the repeated visual presentation of affectively unpleasant stimuli compared to pleasant stimuli (Bradley et al., 1993). The apparent automaticity of attentional capture by affective stimuli suggests that ERP measures of perception and evaluation may be less likely to habituate. To test this, Schupp and colleagues (2006b) presented 90 emotional image repetitions to participants and found no evidence of EPN attenuation across repetition. A similar study investigating LPP habituation also revealed no attenuation across 60 emotional image repetitions (Codispoti et al., 2006).

In summary, these ERPs considered indices of selective attention for motivated attention are also observed under conditions of instructed attention such as those typical of an AB study. Together, the EPN and LPP may reflect both the instructed and emotional guidance of selective attention with the EPN being indicative of an early stimulus processing stage and the LPP of stimulus consolidation in working memory. Furthermore, habituation studies demonstrate that the EPN and LPP elicited by the presentation of emotionally arousing visual stimuli are reliably enlarged compared to those elicited by neutral stimuli regardless of stimulus novelty. This lack of habituation may highlight the importance of detecting emotionally arousing environmental stimuli by suggesting that their detection is obligatory.

2.4 Emotional Processing as a Secondary Task

During primary attention tasks requiring relatively few cognitive resources, there appears to be little interference in the differential processing of emotional stimuli compared to neutral stimuli (Schupp et al., 2003b). When primary attentional tasks require intense focus and thus more cognitive resources, the differential processing of emotional stimuli compared to neutral stimuli appears greatly attenuated based on ERP measures (Schupp et al., 2003b). These results suggest that there is an attentional capacity limit and that attending to task-related stimuli can interfere with the processing of secondary emotional stimuli if the cognitive load of the primary task is sufficiently high.

2.5 Attentional Demands of Stimuli with Learned Salience

It is clear that emotional cues are able to capture attention, but it can be difficult to accurately define what an emotional cue is because what may be a highly affective and motivating stimulus to one person may be completely neutral to another. For example, an arachnologist may find an image of a spider relatively uninteresting while an individual with arachnophobia could be quite startled. This difference in reaction warrants investigation into the possible differences in attentional capture of stimuli with relevance learned through personal experience.

Several studies have demonstrated that exposure to fear-related visual stimuli can modulate the same ERP amplitudes as those implicated in emotional processing. To take the same example, spider-related stimuli elicited larger EPN and LPP amplitudes in individuals with arachnophobia compared to a control group (Miltner et al., 2005, Wiens et al., 2022). Given that many theories of addiction posit that increased salience is attributed to addiction-related stimuli (Robinson & Berridge, 1993; Brand et al., 2019), researchers have applied a methodology similar to those of the phobia studies to examine how the attributed salience of drug-related stimuli may modulate ERP responses of individuals with addiction. In these studies, drug-related stimuli elicit an enlarged LPP amplitude in those with addiction compared to control participants (Dunning et al., 2011; Franken et al., 2003, 2004).

Differences in EPN are not statistically significant across groups in these experiments, but one possibility is that drug-related stimuli are commonly stigmatized and therefore equally capable of early attentional capture across experimental groups. The differences in LPP amplitudes reflect a difference in the stage of representation consolidation in which stimuli are likely processed for the purposes of further cognitive or emotional elaboration.

These findings are informative additions to the growing body of evidence that learning and experience prompt and modulate physiological responses to clinically-relevant stimuli (Öhman et al., 2000a; Moretta & Buodo 2021a,b; Globisch et al., 1999). Through numerous forms of direct or indirect exposure to particular stimuli, personal salience attributions may affect how these stimuli are selectively attended to and processed by an individual. ERP measures are sufficiently sensitive to indicate at what stage of attentional processing clinically-relevant stimuli may differ across groups and to detect cognitive modulations that may not be measurable behaviorally. Given the success of this methodology in these studies, ERP measurements hold promise as potential tools to monitor the progress of individuals undergoing behavioral therapy for any number of conditions such as phobias, substance abuse, obsessive-compulsive disorder, etc.

2.6 Foundations of the Study of Problematic Use of Social Media

The study of PUSM is, of course, a new area in the field of psychology appearing only within the last 30 years. The research in this area is highly informed by theories of addiction, though PUSM is not at this time considered an addiction itself. Despite its lack of status in diagnostic manuals as an addiction, PUSM shares many similarities with other addictive behaviors and often even with substance addiction (Moretta et al., 2022; Morris et al., 2023). An in-depth review of the major theories of addiction is outside the scope of this review, but their importance for the theoretical foundations of the study of PUSM cannot be overstated (for the interested reader, see Robinson & Berridge, 1993; Koob & Le Moal, 2008; Hogarth, 2020; Everitt & Robbins, 2016; Brand et al., 2016). Many of these addiction theories share the proposition that addiction-related stimuli, in one way or another, become especially salient to individuals suffering from addiction. Given the importance of stimulus salience in addiction literature, it is no surprise that motivated attention is a prominent area of focus within the field of study of PUSM.

Currently, there is not a clear characterization of PUSM and there is a lack of psychophysiological studies that may help define PUSM. The lack of a set of agreed-upon criteria renders studies on the topic difficult to compare because the methods by which different researchers identify individuals with PUSM and the severity of their problematic use are widely variable. However, most theorists support the idea that PUSM is distinguished by excessive concern about the use of social media, impaired control over social media use, and an excessive amount of time spent on social media such that it negatively impacts important areas of life (Andreassen, 2015; Andreassen & Pallesen, 2014; Morris et al., 2023).

The I-PACE (Interaction of Person, Affect, Cognition, and Execution) model provides a conceptual framework for understanding behavioral addictions and issues related to internet use (Brand et al., 2019). According to this model, the development of PUSM is dependent upon the interaction between an individual's predisposing genetic and personality traits, unique cognitive biases, emotional responses to environmental stimuli, and a reduction in executive control. Like other addictive behaviors, prolonged use of social media can give rise to habitual behaviors that become compensatory and provide diminishing satisfaction (Koob & Le Moal, 2008). Consequently, those with a reduced capacity to inhibit the use of social media may be vulnerable to developing PUSM. In later stages, conditioning mechanisms may result in heightened cue reactivity to social-media-related stimuli, which may lead to cravings and a decline in inhibitory control. As a result, these individuals exhibit repetitive, habitual social-media-related behaviors and diminished control over the use of social media. While there is not enough research to thoroughly support all the predictions of this model, its general framework is a solid basis with which to make reasonable assumptions about PUSM. However, experimental results have yet to conclusively support or reject the role of cue reactivity in PUSM as it is proposed by the I-PACE model. The manner in which cue reactivity and its modulation contribute to PUSM are still debated and require further investigation.

2.7 ERP Studies of Cue Reactivity in the Context of Problematic Use of Social Media

Both Go/NoGo and passive viewing tasks have been widely utilized for the assessment of cue reactivity associated with PUSM. These methods have proven instrumental in combination with electrophysiological measures as a means of investigating cognitive changes that are often not behaviorally observable.

2.7.1 Go/NoGo

In a Go/NoGo task with Facebook users who either had or did not have problematic Facebook use, results revealed that those with problematic Facebook use were less accurate for both Go and NoGo trials compared to those without problematic Facebook use (Moretta & Buodo, 2021a). This reduced accuracy held true for Facebook-related, pleasant, unpleasant, and neutral stimuli. The NoGo-N2 and NoGo-P3 amplitudes were taken as respective measures of response-conflict detection and successful response inhibition. Moretta and Buodo (2021a) and Gao and colleagues (2019) found that the NoGo-N2 amplitude of individuals with and without PUSM was larger for social-media-related stimuli compared to pleasant, unpleasant, and neutral stimuli. The enlarged NoGo-N2 may reflect a high demand for neural resources related to conflict monitoring in the early stages of inhibitory control (Donkers & van Boxtel, 2004), so these findings suggest that greater response conflict is generated in the presence of social-media-related NoGo stimuli, which renders response selection more cognitively demanding.

The same two research groups found a group difference in NoGo-P3 amplitudes; however, their results differ. In one study, individuals with problematic Facebook use exhibited smaller NoGo-P3 amplitudes in response to Facebook-related, pleasant, and neutral stimuli compared to unpleasant stimuli (Moretta & Buodo, 2021a). The smaller NoGo-P3 amplitudes suggest a reduced inhibition efficiency in the presence of Facebook-related, pleasant, and neutral stimuli.

In a different study, these same results were not found. Instead, in a similar Go/NoGo task, individuals with PUSM exhibited a reduced NoGo-P3 compared to individuals without PUSM across all stimulus types (Goa et al., 2019). In this case, the difference in the NoGo-P3 component between groups suggests a general reduction of inhibitory control in those with PUSM, regardless of stimulus type. A similar reduced inhibitory control has been documented in relation to other behavioral addictions and substance use disorders, but these results unexpectedly conflict with findings regarding problematic use of the internet (Dong et al., 2010; Littel et al., 2012).

2.7.2 Passive Viewing

In one study utilizing a passive viewing task to analyze several LPPs, Facebook users with and without problematic Facebook use viewed Facebook-related, pleasant, unpleasant, and neutral stimuli. These long-latency components likely reflect late evaluative processes of emotional stimuli and representation of stimuli in short-term memory (Hajcak et al., 2010). In the task, Facebook-related and negative emotional cues elicited a larger LPP amplitude 400 – 600 ms after stimulus presentation compared to neutral cues in all participants (Moretta & Buodo, 2021b). This enlarged LPP amplitude likely reflects greater cue reactivity to

Facebook-related and unpleasant stimuli, and these results further suggest that Facebook-related cues may acquire motivational significance regardless of whether or not Facebook use is excessive. Reinforcement processes such as the pairing of Facebook-related cues with Likes or positive comments may drive this process of acquired salience.

Later LPP component modulations have also been observed in response to affective and social-media-related cues, but there have been very few studies assessing these later ERP modulations in the PUSM-related literature. When exposed to pleasant images, individuals with problematic Facebook use exhibit a heightened amplitude in the LPP component, occurring 600 – 800 ms post-stimulus compared to unpleasant images (Moretta & Buodo, 2021b). This heightened positivity suggests prolonged attention to and potentially delayed disengagement from pleasant content, implying a sustained focus on such stimuli. Furthermore, this enlarged 600 – 800 ms post-stimulus LPP may indicate an exaggerated responsiveness to rewarding stimuli in individuals with problematic Facebook use.

In a subsequent stage of processing indexed by a later LPP 800 –1,000 ms post-stimulus, researchers observed a seemingly contradictory result. Analysis revealed that among those with problematic Facebook use, a greater reported craving for Facebook was correlated with a reduced LPP in response to both pleasant and unpleasant images (Moretta & Buodo, 2021b). This finding suggests that in individuals with problematic Facebook use who report higher craving, there is a reduction in attentional processing of motivationally salient stimuli, such as natural rewards and threats unrelated to Facebook cues, compared to individuals with problematic use who report lower craving. This result is similar to the blunted emotional responses seen in those with substance use disorders (Verdejo-Garcia & Perez-Garcia, 2006).

Moretta and Buodo (2021b) propose that these blunted responses in individuals with problematic Facebook use reporting greater cravings may be the result of diminished capacities or reduced tendencies to experience and regulate emotions. This diminished emotional regulation may then enable the sense of craving to seize a larger share of motivational and attentional resources.

Importantly, recent studies have not identified any discernible behavioral differences between individuals with and without problematic Facebook use in the lab. Differences in ERPs, such as the LPP, have not been mirrored in self-reported valence and arousal ratings (Moretta & Buodo, 2021b). This underscores the importance of employing sensitive neuroimaging techniques in investigating the motivational processes associated with Facebook and other social media platforms, which might otherwise remain unnoticed through subjective assessments (Brand et al., 2020; Moretta & Buodo, 2021b). However, additional behavioral tasks should be implemented and complemented with physiological measures in order to further assess any possible attentional changes across the course of PUSM development.

2.8 Chapter Summary

Motivated attention is critical to the understanding of cue reactivity in PUSM. In the study of emotion, two motivational subsystems, the approach system linked to pleasant states and the withdrawal system linked to negative states, play a crucial role (Schneirla, 1959; Konorski, 1967; Dickinson & Dearing, 1979; Lang et al., 1990, 1997; Schupp et al., 2006a). Research supports the hypothesis that these subsystems, influenced by arousal levels, prepare individuals for approach or avoidance behaviors (Lang et al., 1990, 1997; Frijda, 1986; Schupp et al., 2006a). These emotional subsystems are not only evident in behavior but also in autonomic, somatic, and reflex responses to emotional stimuli (Bradley, 2000; Hamm et al., 2003). Adopting the idea that emotions serve as action dispositions, these responses reflect preparations for appropriate behavioral reactions, which require information extraction from the environment. Aiding in the process of information extraction, emotional cues can effectively direct attentional resources, especially when highly arousing, irrespective of their emotional valence (Junghöfer et al., 2001; Bradley et al., 2001).

Although highly arousing emotional cues are likely to capture attention in general, that which constitutes an emotional cue can vary widely from person to person due to personal experiences. Studies have shown that exposure to specific phobia-related visual stimuli can affect ERP amplitudes associated with emotional processing (Miltner et al., 2005, Wiens et al., 2022). Similarly, drug-related cues elicit an enlarged ERP response in individuals with addiction (Dunning et al., 2011; Franken et al., 2003, 2004). These findings highlight how personal experiences and learning shape our attention and emotional responses.

In passive viewing tasks, the modulations of the emotional EPN and LPP appear strikingly similar. Specifically, these modulations appear resistant to habituation and are most pronounced when individuals are exposed to highly arousing pleasant or unpleasant stimuli (Schupp et al., 2006b; Codispoti et al., 2006).

One critical question is the extent to which the EPN component reflects an automatic phenomenon characterized by unintentional, unconscious, and effortless processing of emotional cues. This issue is important given the utility of this ERP in many studies across numerous subfields of psychology and neuroscience, which may rely on the assumption that the EPN reflects an automatic process. Indicative of its automaticity, EPN modulation in response to emotional cues persists across repeated presentations of the same materials, even in the absence of explicit task instructions (Schupp et al., 2006b). Consequently, it appears that selective emotional processing occurs unintentionally and effortlessly, presumably preceding conscious recognition.

Importantly, the EPN can be influenced by intentional goals and the processing of immediately preceding emotional cues (Schupp et al., 2003b). This influence suggests that when viewing concurrent and successively presented pictures, distinct neural representations may compete for a limited pool of processing resources, potentially attenuating or even extinguishing selective emotional processing. In sum, these findings align with the notion of component-based features of automaticity rather than adhering to a strict all-or-nothing concept of automatic processing, as proposed by Bargh (1989).

These ERP components may prove useful in the investigation of PUSM because of their potential as indices of cue reactivity. The study of PUSM, though not officially classified as an addiction, shares similarities with addictive behaviors (Moretta & Buodo, 2021; Gao et al., 2019; Antons et al., 2020; Weinstein & Lejoveux, 2010). PUSM involves excessive preoccupation with social media, impaired executive control, and negative life impacts. The I-PACE model provides a framework for understanding PUSM, highlighting the interplay of genetics, cognition, emotions, and executive control (Brand et al., 2019). Like other addictions, prolonged social media use can lead to habitual, unsatisfying behaviors. However, the role of cue reactivity in PUSM, as proposed by the model, remains debated and requires further investigation.

Several studies have employed Go-NoGo and passive viewing tasks in tandem with electrophysiological measures to assess cue reactivity in the context of PUSM, but much more research is necessary to characterize PUSM and determine if and how cue reactivity may differ in individuals with PUSM compared to the general population and to individuals afflicted with other behavioral addictions or substance disorders. To this end, the following chapters detail a study intended to assess cue reactivity in individuals with PUSM in a novel manner by exploiting the robustness of the EAB paradigm and the sensitivity of ERP measures. This review, along with that of chapter one, serves as both the theoretical and methodological foundation of the investigation and lays the essential, historical groundwork upon which the subsequent chapters will build in order to foster a comprehensive understanding of the project's significance and contributions to the field.

Chapter 3: Methods

Based on a review of the literature, an EAB experiment was designed and four hypotheses were formed.

Hypotheses:

- H1: People who score higher on problematic Instagram use will have a more pronounced emotional attentional blink after Instagram-related stimuli compared to those who score lower, and this will be reflected in their reduced target report accuracy.
- H2: People who score higher on problematic Instagram use will have a more pronounced emotional attentional blink after pleasant stimuli compared to those who score lower, and this will be reflected in their reduced target report accuracy.
- H3: People who score higher on problematic Instagram use will have enlarged EPN and LPP components in response to images of erotica and Instagram-related images compared to those who score lower.
- H4: Lower target report accuracy will correlate to an enlarged LPP component, but target report accuracy will not correlate to an enlarged EPN component.

3.1 Participants

Participants were recruited informally by word of mouth and by soliciting student WhatsApp group chats at the University of Padova. In total, 96 participants were recruited, but 6 were excluded from the analysis because of either drug use 24 hours before the experimental session or the consumption of more than 2 alcoholic beverages 24 hours before the experimental session. The final sample consisted of 90 total participants (63 female, 27 male). For the whole sample, mean age = 23.17 ± 2.63 with ages ranging between 18 – 32. For the females, mean age = 22.92 ± 2.17 with ages ranging between 20 – 29. For the males, mean age = 23.74 ± 3.40 with ages ranging between 18 – 32. All participants had completed at least 12 years of education. Participants also reported normal or corrected-to-normal vision and no task-concurrent use of psychoactive drugs. For all participants, behavioral data was collected. For 34 participants, both behavioral and EEG data was collected, but three participants' data was excluded from analysis because of technical issues while recording. Two more participants were excluded because of drug use less than 24 hours before the session. In total, 29 participants (19 female, 10 male) were included for EEG data analysis.

Table 1. General Demographic information.

Sex	*Age*	*Education*	*Language*
63 Female	20 – 29 mean = 23.17 ± 2.63	12 – 25 mean = 16.68 ± 2.14	44 English 19 Italian
27 Male	18 – 32 mean = 23.74 ± 3.40	12 – 23 mean = 16.51 ± 2.50	13 English 14 Italian

3.2 Self-Report Measures

Questionnaires were administered in the lab immediately following the task using Qualtrics software (Qualtrics, Provo, UT). Participants could choose to either complete the questionnaires in English (57 participants) or Italian (33 participants).

- **Depression, Anxiety, and Stress Scale (DASS-21).** The 21-question version of the Depression, Anxiety, and Stress Scale (DASS-21) (Henry & Crawford, 2005) is the short form of the 42-item DASS scale (Lovibond & Lovibond, 2004) and was used to assess the severity of symptoms of depression, anxiety, and stress of participants based on the seven days prior to their completion of the questionnaire. In this self-report inventory, participants are presented with statements, such as “I found it hard to wind down” or “I felt I was using a lot of nervous energy”, and were asked to rate how much each statement applied to them from 0 (Does not apply to me at all) to 3 (Applied to me very much or most of the time). Each of the three DASS-21 subscales consists of seven items for both the English and Italian versions. The tridimensional factor structure and appropriate psychometric properties have been validated in both English-speaking (American and British) and Italian samples (Kia-Keating et al., 2018; Henry & Crawford, 2005; Bottesi et al., 2015). For the unidimensional model of the DASS-21 in this sample, scores ranged from 1 – 54, and Cronbach’s α = .93 (Depression α = .9, Anxiety α = .87, Stress α = .82). DASS-21 mean score = 19.51 ± 12.74 (Depression mean = 6.11 ± 5.17, Anxiety mean = 5.36 ± 4.84, Stress mean = 8.04 ± 4.06).

- **Bergen Social Media Addiction Scale adapted for Instagram (BSMAS-I).** The Bergen Social Media Addiction Scale (BSMAS; Andreassen et al., 2016) is a 6-item, self-reported questionnaire with each question answered on a 5-point Likert scale. The answers range from very rarely (1) to very often (5) and a composite score from 6 – 30. The items refer to experiences during the past year (e.g., “How often during the last year have you tried to cut down on the use of social media without success?”). The questions are based on a component model of addiction (Griffiths, 2005). These components include salience, mood modification, tolerance, withdrawal, conflict, and relapse. The unidimensional factor structure and appropriate psychometric properties have been validated in English-speaking (American and British) and Italian samples

(Brailovskaia & Margraf, 2022; Monacis et al., 2017). The BSMAS was adapted for this study to refer specifically to Instagram instead of to social media in general. This modified version will hence be referred to as the BSMAS-I. The BSMAS-I score served as a measure of the severity of problematic Instagram use. For the BSMAS-I in this sample, scores ranged from 6 – 27, and Cronbach's α = .76. Mean = 13.81 ± 4.74.

- **Internet Motives Questionnaire adapted for Instagram (IMQ-I).** To assess motives for Instagram use, the Internet Motives Questionnaire for Adolescents (IMQ-A; Bischof-Kastner et al., 2014) was adapted for Instagram. The IMQ-A is a 16-item, self-reported questionnaire with each question answered on a 5-point Likert scale. The answers range from almost never (0) to almost always (4). The items refer to experiences during the past year (e.g., "How often do you go online to forget your worries?") and are adapted from a motivational model of alcohol use (Cox & Klinger, 1988). The motives are based on valence (Positive: to increase positive feelings or Negative: to decrease negative feelings) and source (Internal: with respect to one's own body sensations, and External: with respect to significant others) and include coping, social, enhancement, and conformity (Cox & Klinger, 1988).

Table 2. Combinations of valence and source define the motives measured with the IMQ-A

Source	*Positive Valence*	*Negative Valence*
Internal	Enhancement motives	Coping motives
External	Social motives	Conformity motives

This scale has been validated with its four-dimensional structure and appropriate psychometric properties in Italian samples (Langher et al., 2019). However, these samples were of adolescents with a maximum age of 19. Importantly, a version of the IMQ-A adapted for Facebook (Marino et al., 2016) was validated for an Italian sample of university students, so the use of this scale for a sample older than 19 years of age likely poses no issue. For this study, the questionnaire is identical to the IMQ-A adapted for Facebook with the only difference being the word Instagram in place of Facebook. To this author's knowledge, the IMQ-A is the only scale that has been validated to assess motives for internet use in Italian and is available in English; therefore, it was selected as the only viable questionnaire to measure these motives in this particular study involving an international sample heavily biased with Italian participants. While the scale is available in English, this author was unable to find any validation of this scale for an English-speaking population. However, an English validation of the scale is beyond the scope of this project. The modified version of the IMQ-A will hence be referred to as the IMQ-I. For the IMQ-I in this sample, scores ranged from 0 – 48, and Cronbach's α = .86 (Coping α = .87, Social α = .87, Enhancement α = .8, Conformity α = .73). IMQ-I mean score = 22.88 ± 10.83 (Coping mean = 5.7 ± 4.03, Social mean = 8.11 ± 4.31, Enhancement mean = 6 ± 3.88 Conformity mean = 3.07 ± 3.1).

- **Demographic questionnaire.** Participants also answered a demographic questionnaire to assess age, sex, gender, sexual orientation, ethnicity, personal and family income, education, and sleep. This same questionnaire probed information used for the exclusion of participants by assessing the presence of neurological disorders, psychoactive medications, recent alcohol use, and recent drug use.

Table 3. Descriptive statistics of demographics and self-report measures for EEG participants.

Sex	*10 Male*	*19 Female*
Age	20 – 32 mean = 23.6 ± 3.32	20 – 27 mean = 23.11 ± 1.80
Education	14 – 23 mean = 16.7 ± 2.33	14 – 20 mean = 16.68 ± 2.14
Language	4 English 6 Italian	12 English 7 Italian
DASS-21	2 – 28 mean = 11.7± 8.73	6 – 36 mean = 17.42 ± 8.31
BSMAS-I	6 – 17 mean = 10.7 ± 3.88	6 – 27 mean = 14.57 ± 5.61
Coping	0 – 15 mean = 4.2 ± 4.51	0 – 15 mean = 7.21 ± 4.30
Enhancement	0 – 16 mean = 6.1 ± 4.48	0 – 13 mean = 6.53 ± 3.84
Social	0 – 15 mean = 5.4± 3.9	1 – 16 mean = 9.32 ± 4.43
Conformity	0 – 4 mean = 1.6 ± 1.42	0 – 11 mean = 3.63 ± 2.96

3.3 Task, Stimuli Selection, and Materials

3.3.1 Task Description and Stimuli Selection

The experimental task was comprised of 315 RSVP streams. In each stream, the first 4 – 6 items presented were neutral objects. After these first 4 – 6 objects, either a neutral, pleasant, or Instagram-related image was presented. Following this affective image, 0 – 9 neutral objects were presented. Then, the target image, a fruit, was presented followed by more images of neutral objects such that the total number of images shown in each RSVP stream was 21. In sum, there were three categories of affective images (neutral, pleasant, Instagram-related), seven different lags (1, 2, 3, 4, 6, 8, 10), and each lag and category combination was presented fifteen times (3 × 7 × 15) for a total of 315 RSVP streams presented. Given that, at lag 10, there is too much time for an EAB to impact target detection, lag 10 was used as the control condition against which all other effects of lag were compared.

All images were digitally edited to have the same pixel resolution (600 × 800 pixels). The pleasant images were erotic images of heterosexual couples. The neutral images were of natural (e.g., buffalo in the snow) or man-made (e.g., a shipyard) scenes. The pleasant, neutral, and object images were all selected from the International Affective Picture System repository (IAPS; Lang et al., 2008). Affectively neutral and object images were matched for normative (neither high nor low) arousal ratings (neutral = 3.2100 ± .68; object = 3.0805 ± .52), which were lower than for affectively pleasant images (pleasant = 6.4385 ± .33; $p < .0001$). The same was done for valence of affectively neutral and object images (neutral = 5.2890 ± . 0.54; object = 5.0315 ± .35), which were lower than for affectively pleasant images (pleasant = 6.6280 ± .43; $p < .0001$).

The 20 Instagram images were gathered form Pixabay.com, an image repository that does not require permission for commercial use. The images were carefully selected to include a phone with Instagram related content (e.g., Instagram logo, Instagram sign-in page, etc.). The images were also selected such that the majority of the possible Instagram images presented in the task also contained either a human hand holding the phone or human figures in the background of the image. This selection procedure is an additional measure to ensure that any differences in results between the Instagram and affectively pleasant images is not solely due to the presence of human features in one set and not the other. Targets were 20 images of fruits that were also gathered from Pixabay.com. The specific fruit images were the same used by Santacroce and colleagues (2023), contained both whole and sliced fruit, and were carefully selected so that they could all be easily distinguishable from one another.

3.3.2 Stimulus Presentation and Response Selection

For stimulus presentation and response selection, Opensesame software (Mathôt et al., 2012) was used on two different computers. The first was a PC utilizing Opensesame version 3.3.14, which was necessary in order to relay triggers for later ERP analysis. The second was a MacBook utilizing Opensesame version 4.0.1, which was not compatible with EEG data collection. Behavioral data collected with either computer was included in the analysis. The refresh rate for both screens was 60hz; therefore, images could be shown every $\frac{1}{60}$ of a second, or every 16.67 ms. Because of this timing, each image in the RSVP stream was presented for a total of 83.35 ms, a multiple of 16.67. This value was decided upon after pilot data showed a ceiling effect with a presentation time of 100 ms.

3.3.3 EEG Data Acquisition and Preprocessing

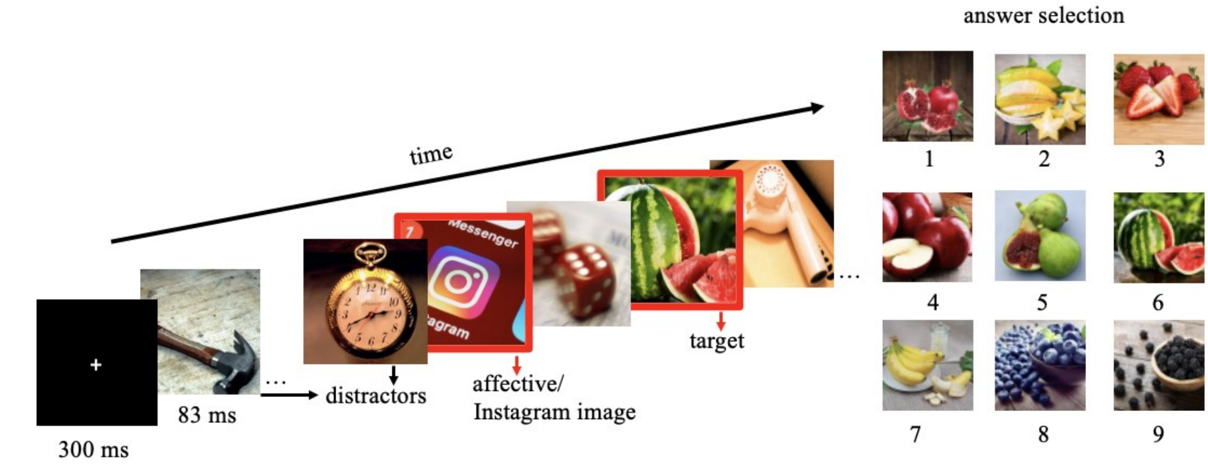
Electroencephalographic activity was recorded from 11 scalp sites (Fz, F3/4, Cz, C3/4, Pz, P3/4, O1/22), placed according to the 10-20 system (Jasper, 1958; Sharbrough et al., 1991) using an elastic cap with a ground positioned over AFz. Horizontal and vertical electro-ocular activity was measured with electrodes placed above and below the right eye and laterally to the canthus of each eye. Electrode impedances were kept below 5kΩ. Raw signal was continuously registered with a sampling rate of 500 Hz through a V-Amp amplifier (Brain Products GmbH, Munich, Germany). Offline, data processing was performed with Brain Vision Analyzer 2 software (Brain Products GmbH, Munich, Germany). EEG data were initially downsampled to 250 Hz and re-referenced to the mastoids. A notch filter of 50Hz and a bandpass filter of .1 – 30Hz were applied, and eyeblink artifacts were corrected by an independent component analysis algorithm. Continuous EEG signals were segmented separately for neutral, pleasant, and Instagram-related stimuli into 1052 ms epochs (252 ms pre-stimulus to 800 ms post-stimulus onset). A baseline correction algorithm was applied referencing this 252 ms pre-stimulus interval. All trials were semiautomatically screened for technical, muscle-related, or movement-related artifacts with amplitude deviations of ±80 μV, and trials with deviations surpassing this threshold were rejected from the analysis.

ERPs were obtained by averaging trials separately for each subject, electrode site, and affective image category (neutral, pleasant, Instagram-related). Using R software (R Core Team, 2022), magnitudes of the EPN component were extracted from these averaged waveforms as mean activity in the previously-determined time interval of 150 – 300 ms after affective image onset from five electrode sites (Pz, P3/4, O1/2). Magnitudes of the LPP component were extracted from these averaged waveforms as mean activity in the previously-determined time interval of 400 – 600 ms after affective image onset from six electrode sites (Cz, C3/4, Pz, P3/4). These same sites were used to extract the magnitudes of the P3 component (260 – 360 ms post-stimulus onset) and the LPP2 (600 – 800 ms post-stimulus onset) for exploratory analysis.

3.4 Procedure

Participants searched RSVP streams for a single target that they would report following each trial. In every trial, the target was preceded by a task-irrelevant stimulus that was either a pleasant, Instagram-related, or neutral image. A varying number of filler items were interposed between these images. Participants were instructed that there was always exactly one fruit. After each RSVP stream the participant was presented with a grid of nine images of fruits from which they were to select with the keyboard the image of the fruit that was presented in the preceding RSVP stream, which is a response method that has been previously validated (Kennedy & Most, 2015). Participants were instructed to guess if they were unsure. Participants completed several questionnaires after completing the task.

Figure 3. Schematic of the trial structure and time course. Participants were asked to correctly identify the target from a forced-choice response selection screen following each RSVP stream



3.5 Power and Sample Size justification

To determine the appropriate sample size, behavioral data was simulated using the "simr" package (version 1.0.7) in RStudio (version 4.2.2). Pilot data from 10 individuals was obtained and the average response accuracy for each lag of interest (i.e., lag values at which the effect is expected to occur) was calculated to serve as the response accuracy values for the simulated data. The largest lag, lag 10, was used as the reference level. Problematic use of Instagram scores (BSMAS-I scores) were randomly generated in a right-skewed gamma distribution ranging from 0 to 1.2. This range was selected because it reflects the range of the BSMAS-I scale (6–30), but because it starts at 0 instead of 1.2, it is easier to manipulate to set the effect size. For the categories in which the effect of problematic use of Instagram is expected, the binary response probabilities decreased as a function of the BSMAS-I score by a factor of .02. Because, to this author's knowledge, no literature exists from which to directly draw an effect size for this effect nor any which details the distribution of scores for problematic use of Instagram, the shape and scale parameter of the gamma distribution and the factor by which the simulated BSMAS-I scores were multiplied were selected based on both theoretical and statistical information.

In theory, the distribution of BSMAS-I scores must be right-skewed with a relatively small scale parameter to reflect the likely distribution of the population. Many people will likely have low BSMAS-I scores, but a few will have high scores, which are indicative of problematic use. Statistically, these distribution parameters were modified based also on their contribution to a result supporting the rejection of the null hypothesis, as is necessary for data simulation. The factor by which these scores were multiplied to determine the probability used to generate a binary response value was the lowest value at which the model yields the intended statistically significant results. This factor guarantees that most the probability of a correct response can decrease due to problematic use of Instagram is less than .025, which appears reasonable given the average response accuracy of the pilot data.

Before running the power analysis with the “simr” package, the variance of the simulated data was set to that of the pilot data, and the minimum effect size was set to -.1. The simulation was run 1000 times for each possible sample size. The results revealed that to reach at least 80% power when alpha = .05, at least 90 participants are required.

Chapter 4: Behavioral Data Analysis and Results

4.1 Descriptive Statistics and Analysis Methods

All analyses were performed using R software (R Core Team, 2022).

In order to have a general understanding of the data, the overall response accuracy sorted by lag and category was plotted, and the shape of the graph is that which would be expected with the presence of an EAB. Upon first glance, accuracy appears to be the lowest at the shortest lags and with non-neutral affective images, and the slope of the graph appears to increase as a function of lag. Figure 4 shows this visualization, and Table 4 corresponds to Figure 4 by showing the mean and standard deviations of response accuracy expressed as a percentage for each combination of lag and affective image category.

Figure 4. Average response accuracy by lag. Note: Error bars denote standard error.

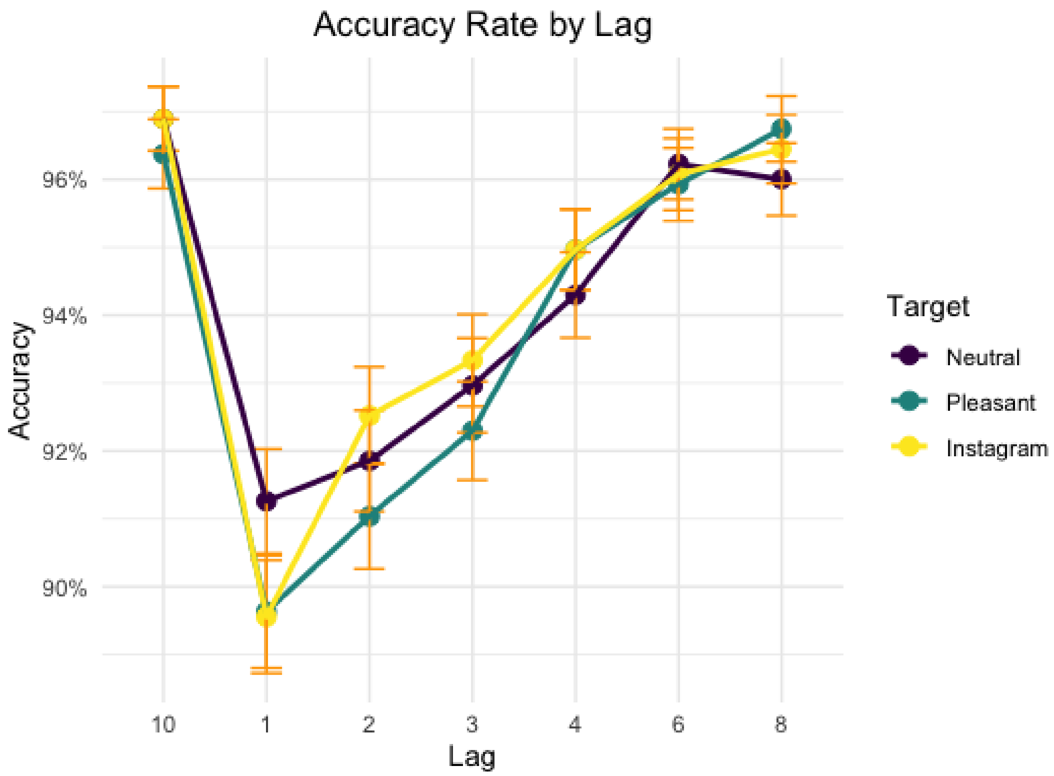


Table 4. Means (and SD) of correct probe detection expressed as percentages.

Lag	*Neutral*	*Pleasant*	*Instagram*
Lag 10	96.89 (17.37)	96.37 (18.70)	96.89 (17.37)
Lag 1	91.26 (28.25)	89.63 (30.50)	89.56 (30.59)
Lag 2	91.85 (27.37)	91.04 (28.58)	92.52 (26.32)
Lag 3	92.96 (25.59)	92.30 (26.67)	93.33 (24.95)
Lag 4	94.30 (23.20)	94.96 (21.88)	94.96 (21.88)
Lag 6	96.22 (19.07)	95.93 (19.78)	96.07 (19.43)
Lag 8	96.00 (19.60)	96.74 (17.76)	96.44 (18.52)

Statistical modeling

The first analysis was conducted utilizing a series of generalized linear mixed-effects models. Participants were denoted as random effects with random intercepts, and BSMAS-I score, affective image category (i.e., neutral, pleasant, and Instagram), and lag were denoted as fixed effects. Akaike information criterion (AIC) and Bayesian information criterion (BIC) fit indices were computed to determine the model that best fits the data.

Secondly, Markov chain Monte Carlo Bayesian estimation methods using the Stan programming language were implemented to fit logistic linear mixed-effects models using the "brms" package (Bürkner, 2017) in RStudio (version 4.2.2). All Bayesian models were fitted using 5,000 iterations on each of four chains. For all model parameters, R-hat < 1.01, indicating perfect convergence. To compare models, the widely applicable information criterion (WAIC; Watanabe, 2010) was employed with lower WAIC values suggesting better model fit. Bayes factors were also computed where appropriate. Not all of these models included informative priors, and for the models specified with only default priors, it was not sensible to select models based on Bayes factors given their heavy reliance on the specified prior distribution. To clarify, obtaining Bayes factors requires the use of integrals over the parameter space, so default distributions defined as priors in that parameter space may assign inappropriately large probability to regions where the true parameter values are implausible. Therefore, a separate set of models including informative and weakly informative priors were also fitted and are described later in this section along with Bayes factors.

Definition and use of prior knowledge

Prior knowledge was taken from the findings reported in the supplementary material of experiment E1B of Santacroce et al. (2023). Normal distributions were used. The observations reported by Santacroce et al. (2023) were estimated probabilities with their corresponding standard deviations. Since logistic regressions were used, these model coefficients were formalized on the logit scale for proper implementation. These parameters can be found in Table 5. For the Instagram category, one model was run assuming uninformative default priors, and another was run with weakly informative priors for the Instagram category. These weakly informative priors were based on the same mean priors used for the pleasant category but with a standard deviation twice the size. Importantly, the priors from Santacroce et al. (2023) were for neutral and unpleasant images, but given that sufficiently arousing stimuli regardless of valence can elicit an EAB, the probability estimates given for unpleasant images were those used to create the informed priors for the pleasant category in this experiment.

Table 5. Parameters of informed prior distributions for model coefficients derived from Santacroce et al. (2023). Coefficients are on the logit scale, and Intercept corresponds to performance at lag 10 in the neutral condition.

COEFFICIENT	MEAN	STANDARD DEVIATION
Intercept	2.4796	0.7822
Pleasant	-0.3484	0.6155
Instagram	-0.3484	1.231
Lag 1	-0.2989	0.7228
Lag 2	-0.1008	0.8625
Lag 3	-0.1401	0.9781
Lag 4	-0.4251	0.8985
Lag 6	-0.0615	1.0511
Lag 8	0.1541	0.9260
Pleasant : Lag 1	-0.7567	0.6471
Instagram : Lag 1	-0.7567	1.2942
Pleasant : Lag 2	-0.8369	0.6733
Instagram : Lag 2	-0.8369	1.3466
Pleasant : Lag 3	-0.9754	0.8644
Instagram : Lag 3	-0.9754	1.7288
Pleasant : Lag 4	-0.7567	0.6317
Instagram : Lag 4	-0.7567	1.2634
Pleasant : Lag 6	-0.3950	0.6546
Instagram : Lag 6	-0.3950	1.3092
Pleasant : Lag 8	-0.1008	0.9680
Instagram : Lag 8	-0.1008	1.936

4.2 Frequentist Results of Behavioral Data

Several generalized linear mixed-effects models were fitted to the data, each with participant set as a random intercept. All models included, at a minimum, the main effects of both category and lag and used the Bound Optimization by Quadratic Approximation method (bobyqa; Powell, 2009). Surprisingly, there emerged two candidates for the best-fitting model, and neither was one in which there was an interaction effect between category and lag.

In the first candidate, category and lag were modeled as main effects with no interaction. This model showed better fit compared to the null model (ΔAIC = -276.89; ΔBIC = -210.88), the model including only category × lag interaction (ΔAIC = -16.57; ΔBIC = -115.61), and the model including a three-way category × lag × BSMAS-I interaction (ΔAIC = -29.66; ΔBIC = -301.99).

In the second candidate, category, lag, and BSMAS-I were modeled as main effects only with no interaction. This model showed a better fit compared to the null model (ΔAIC = -278.21; ΔBIC = -203.94), the model including only category × lag interaction (ΔAIC = -17.89; ΔBIC = -108.67), and the model including a three-way category × lag × BSMAS-I interaction (ΔAIC = -30.98; ΔBIC = -295.06).

Using the AIC and BIC fit indices to compare the two candidate models yields conflicting results: ΔAIC = 1.31; ΔBIC = -6.94. The greater change in the BIC index is likely partially explained by the fact that the BIC fit index more harshly penalizes model complexity than does the AIC index; therefore, the model with three predictors more may have a slightly inflated BIC value due to its less parsimonious specification. Table 6 presents the parameters of both models' fixed effects on the logit scale. Given the similarity between these models, their identical parameter estimates are entirely expected.

Table 6. Conditional and marginal R^2 are reported as well as parameter estimates on the logit scale. Conditional R^2 calculations consider only fixed effects while marginal R^2 calculations consider both fixed and random effects. BSMAS-I was scaled and centered for this analysis and so must be considered in change per standard deviation instead of per unit increase in raw score.

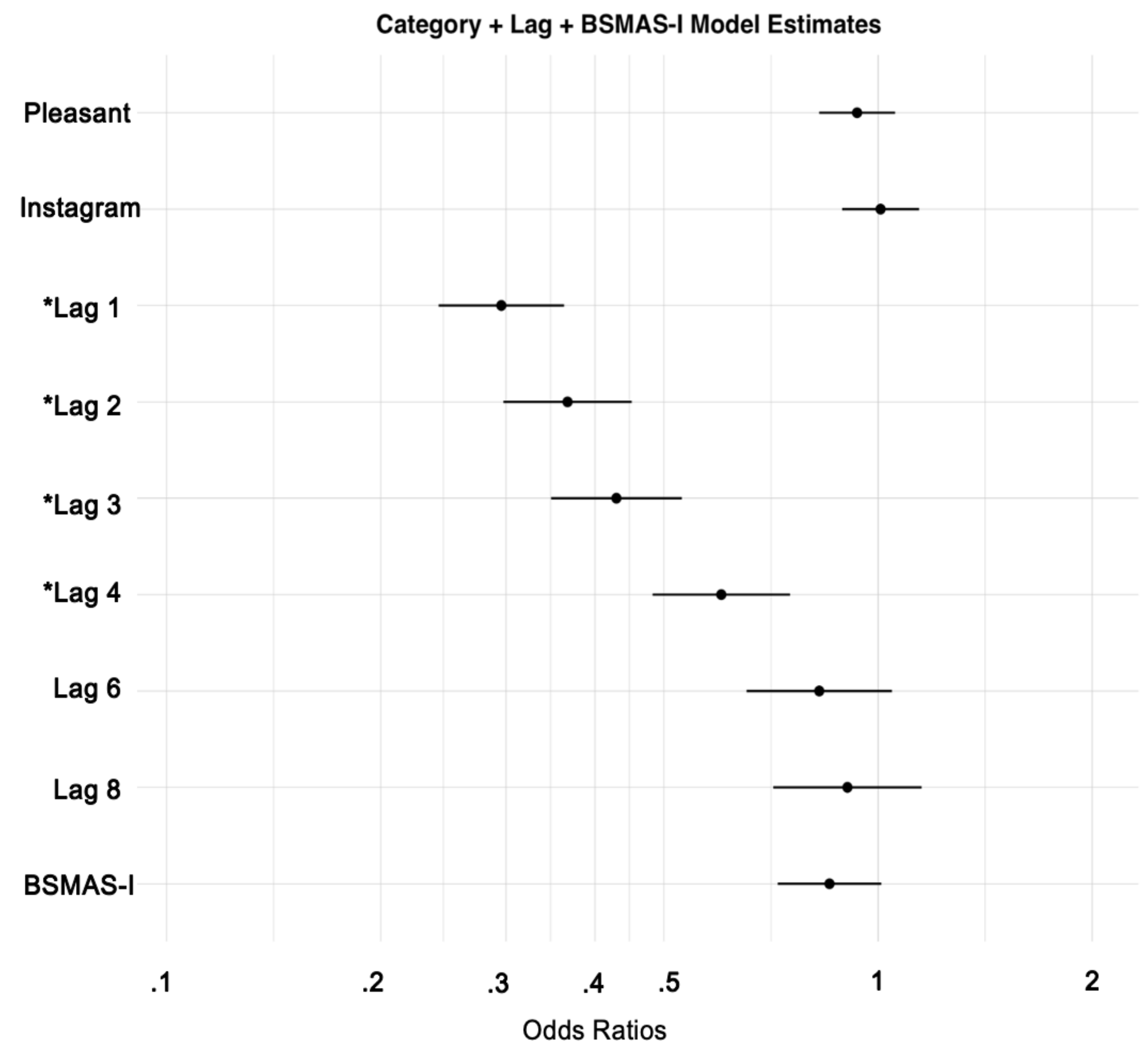
	Category + Lag				Category + Lag + BSMAS-I			
	Conditional R^2 = .197 Marginal R^2 = .054				Conditional R^2 = .197 Marginal R^2 = .048			
Fixed Effects	β	Std. Error	z-value	p-value	β	Std. Error	z-value	p-value
Intercept	3.69	0.13	28.87	p < .001	3.69	0.13	29.13	p < .001
Pleasant	-0.07	0.06	-1.08	.28	-0.07	0.06	-1.08	.28
Instagram	0.01	0.06	0.13	.90	0.01	0.01	0.13	.90
Lag 1	-1.22	0.10	-11.77	p < .001	-1.22	0.10	-11.77	p < .001
Lag 2	-1.00	0.11	-9.49	p < .001	-1.00	0.11	-9.49	p < .001
Lag 3	-0.85	0.11	-7.84	p < .001	-0.85	0.11	-7.84	p < .001
Lag 4	-0.51	0.11	-4.47	p < .001	-0.51	0.11	-4.47	p < .001
Lag 6	-0.19	0.12	-1.59	.11	-0.19	0.12	-1.59	.11
Lag 8	-0.1	0.12	-.81	.42	-0.1	0.12	-0.81	.42
BSMAS-I	-	-	-	-	-0.16	0.09	-1.84	.07

Note: The p-value for the main effect of BSMAS-I does not reach statistical significance, but when the 6 participants that were originally excluded due to recent drug use or recent, heavy alcohol consumption were included, the main effect of BSMAS-I reached statistical significance such that $p < .05$. This may suggest that the study is underpowered with respect to the effect size of BSMAS-I or that these exclusion criteria in some way moderate the main effect of BSMAS-I.

An analysis of several models failed to reveal evidence in support of either a category × lag × BSMAS-I interaction or a category × lag interaction. The models that best fit the data reveal statistically significant main effects of lag at lag 1, lag 2, lag 3, and lag 4. Interpretation is facilitated by exponentiating the estimated parameters of these fixed effects.

According to these models and as shown in Figure 5, at lag 1, one is .30 times as likely to correctly identify the target than they are at lag 10. At lag 2, one is .37 times as likely to correctly identify the target than they are at lag 10. At lag 3, one is .43 times as likely to correctly identify the target than they are at lag 10. Finally, at lag 4, one is .60 times as likely to correctly identify the target than they are at lag 10.

Figure 5. Model estimates for fixed effects from the ***category*** *+* ***lag*** *+* ***BSMAS-I*** *model expressed as odds ratios. Error bars represent the 95% confidence intervals of the odds ratios.*



4.2.1 Post-Hoc Frequentist Results

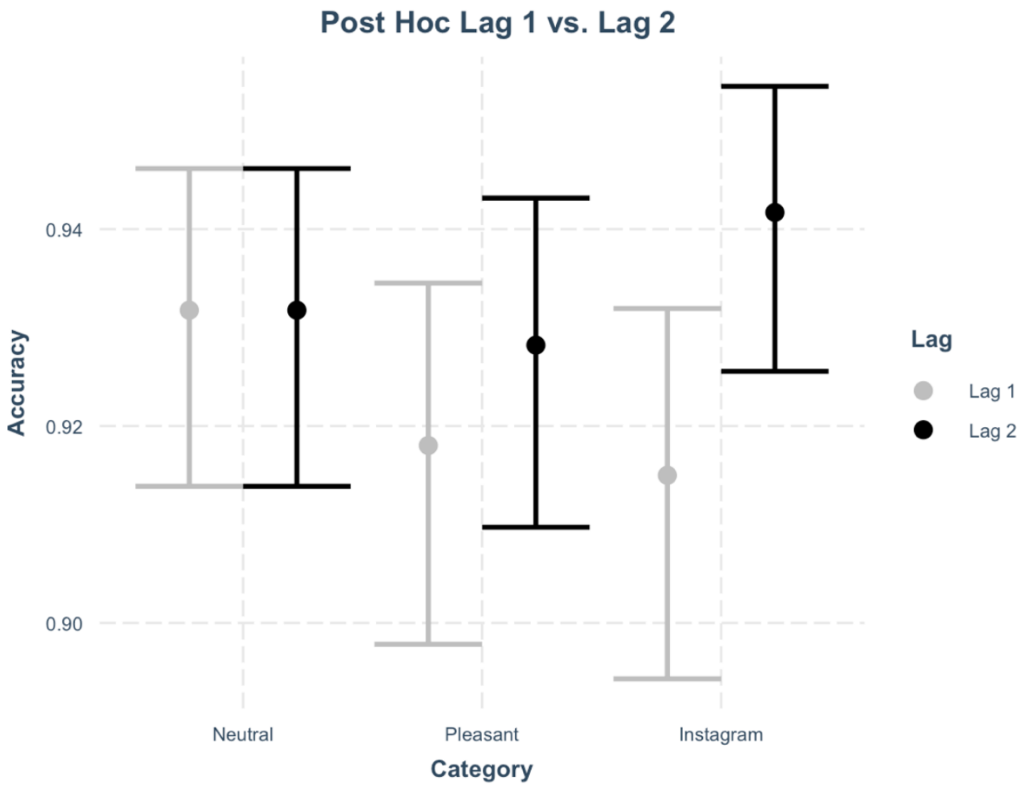
Upon visual inspection of Figure 4, the slope between lag 1 and lag 2 in the Instagram category appears steeper than for the pleasant and neutral category. This prompted the use of a pairwise comparison of lag by category with a, relatively generous, Hommel correction for multiple comparisons (Hommel, 1988). The comparisons of interest were between each lag and its successive lag (e.g., 2-1, 3-2, 4-3) in each category of affective image. These comparisons revealed that only between lags 1 and 2 and only in the Instagram condition was the difference between response accuracy statistically significantly different. Subsequently, the data was subset to include only lags 1 and 2, and a generalized linear mixed-effects model specified with a three-way category × lag × BSMAS-I interaction revealed a main effect of BSMAS-I ($p < .05$), but the interaction effect of category and lag for the Instagram condition at lag 2 compared to lag 1 did not show statistical significance ($p = .12$).

The main effect was such that for every increase in the standard deviation of BSMAS-I, participants were .71 times as likely to correctly identify the target. In other words, a higher problematic use score predicts a diminished response accuracy regardless of category.

A generalized linear mixed-effects model with all 96 participants was also fitted, and in this model, the interaction effect between lag and category was such that participants were 1.5 times as likely to correctly identify the target at lag 2 compared to lag 1 ($p < .05$). This interaction is visualized in Figure 6. However, it must be clearly noted that this model included participants who were excluded from the main analyses.

As a final check, a linear mixed-effects model including DASS-21 as a predictor in a three-way interaction model with category and lag was fitted to both the total data and the subset of lags 1 and 2. No main effect or interaction terms of the DASS-21 were statistically significant.

Figure 6. Interaction of category and lag at lag 1 and lag 2



Note. Accuracy estimates of this figure differ from those of Figure 4 because Figure 4 uses raw mean accuracy values whereas this figure also accounts for random effects.

4.3 Bayesian Results of Behavioral Data

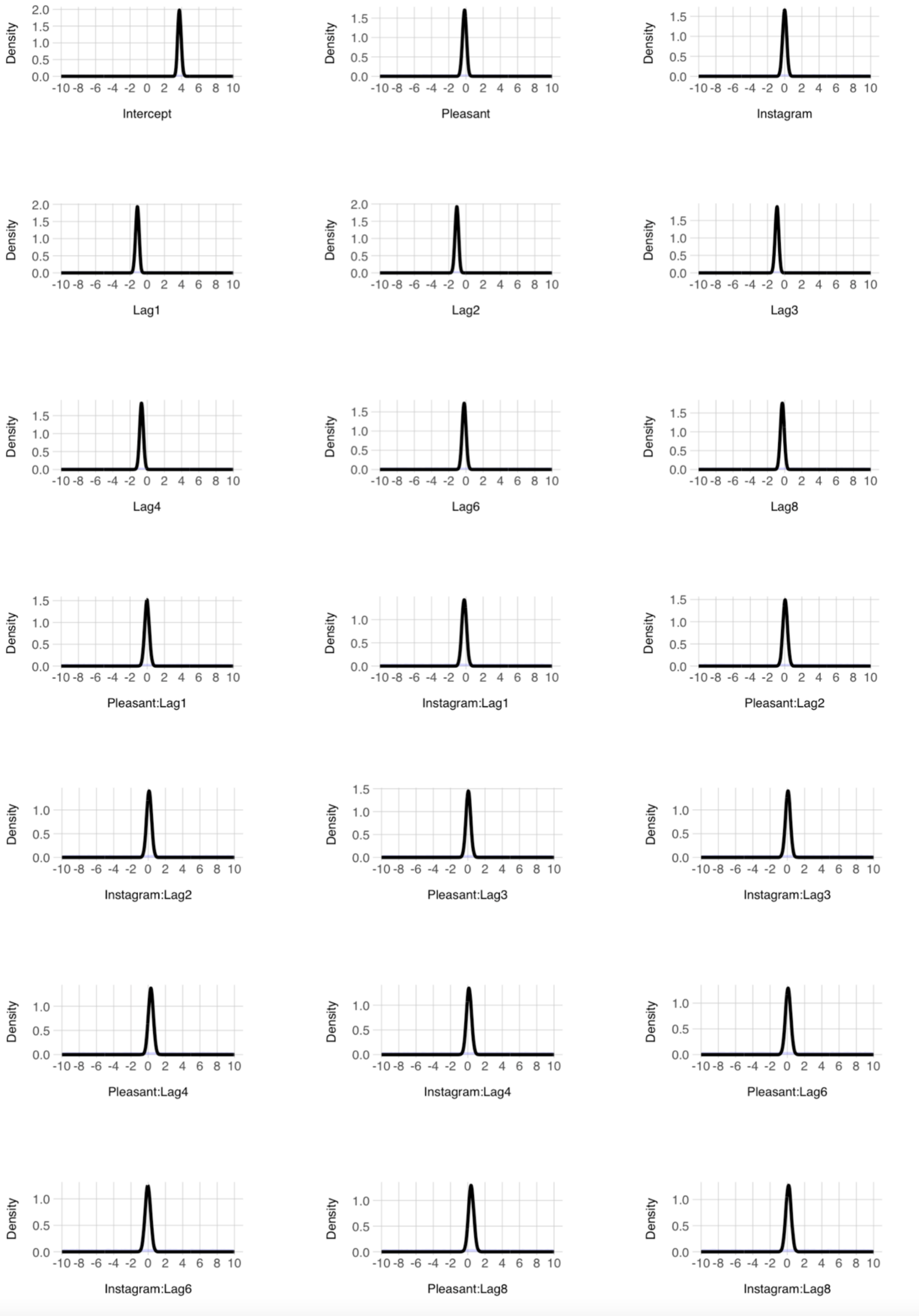
Several Bayesian logistic mixed-effects models were fitted to the data, each with participant set as a random intercept and fitted using a Bernoulli distribution. All models included, at a minimum, the main effects of both category and lag. Again, there emerged two candidates for the best fitting model, and neither was one in which there was an interaction effect between category and lag.

4.3.1 Models Using Uninformative Priors

Unsurprisingly, of the Bayesian models fitted with uninformative priors, the best fitting models mirrored those of the frequentist selection. That is, the model including category + lag main effects and the model including category + lag + BSMAS-I main effects better fit the data when compared to the intercept-only model with ΔWAIC = -278.7 and ΔWAIC = -278.6, respectively. The models also better fit the data compared to the model specifying the original hypothesis of a three-way category × lag × BSMAS-I interaction with ΔWAIC = -33.8 and ΔWAIC = -33.7, respectively. For the two best-fitting models, |ΔWAIC| = .1, which does not suggest strong evidence in favor of one model over the other. Moreover, the same main effects emerged as statistically significant. According to both candidate models, the effect of lag 1 has a greater than 99% probability of being negative (β = -1.22, 95% CI [-1.43, -1.02]) [2] and can be considered significant (< .1% in the region of practical equivalence [ROPE]). The effect of lag 2 has a greater than 99% probability of being negative (β = -1.01, 95% CI [-1.22, -.80]) and can be considered significant (< .1% in ROPE). The effect of lag 3 has a greater than 99% probability of being negative (β = -.85, 95% CI [-1.07, -.64]) and can be considered significant (< .1% in ROPE). The effect of lag 4 has a greater than 99% probability of being negative (β = -.51, 95% CI [-.73, -.29]) and can be considered significant (< .1% in ROPE).

[2] It is imperative to note that the CI here represents the credible interval. The CI is an interval with values reflecting the posterior probability density. This is different from a 95% confidence interval which involves the population parameter and is, as a result of that parameter's being theoretically defined as a point, an object of probability. The 95% confidence interval, however, does not refer to the population parameter itself. It refers to the long-term reliability of the estimation method. By repeating the estimation procedure on many different samples, the proportion of 95% confidence intervals containing the true value of the parameter in the population would approach 95%. The credible interval, instead, represents the plausibility that the parameter in question has those values in particular.

Figure 7. Posterior distributions of the two-way interaction model superimposed on default model priors.



4.3.2 Models Using Informative and Weakly Informative Priors

The models hereinafter discussed are those in which priors were set for all levels of each parameter, except for that of BSMAS-I, for which default priors were used. Importantly and as noted previously, the prior distributions pertaining to the Instagram category parameters (main and interaction effects) were modeled with a greater dispersion than prior distributions pertaining to the pleasant category parameters. The weakening of the Instagram-related priors was meant to reflect the skeptical expectation that the effect of the Instagram-related images would be similar to that of the pleasant images. The interpretations of the Bayes factors elucidated in this and the subsequent subsections are presented in Table 7.

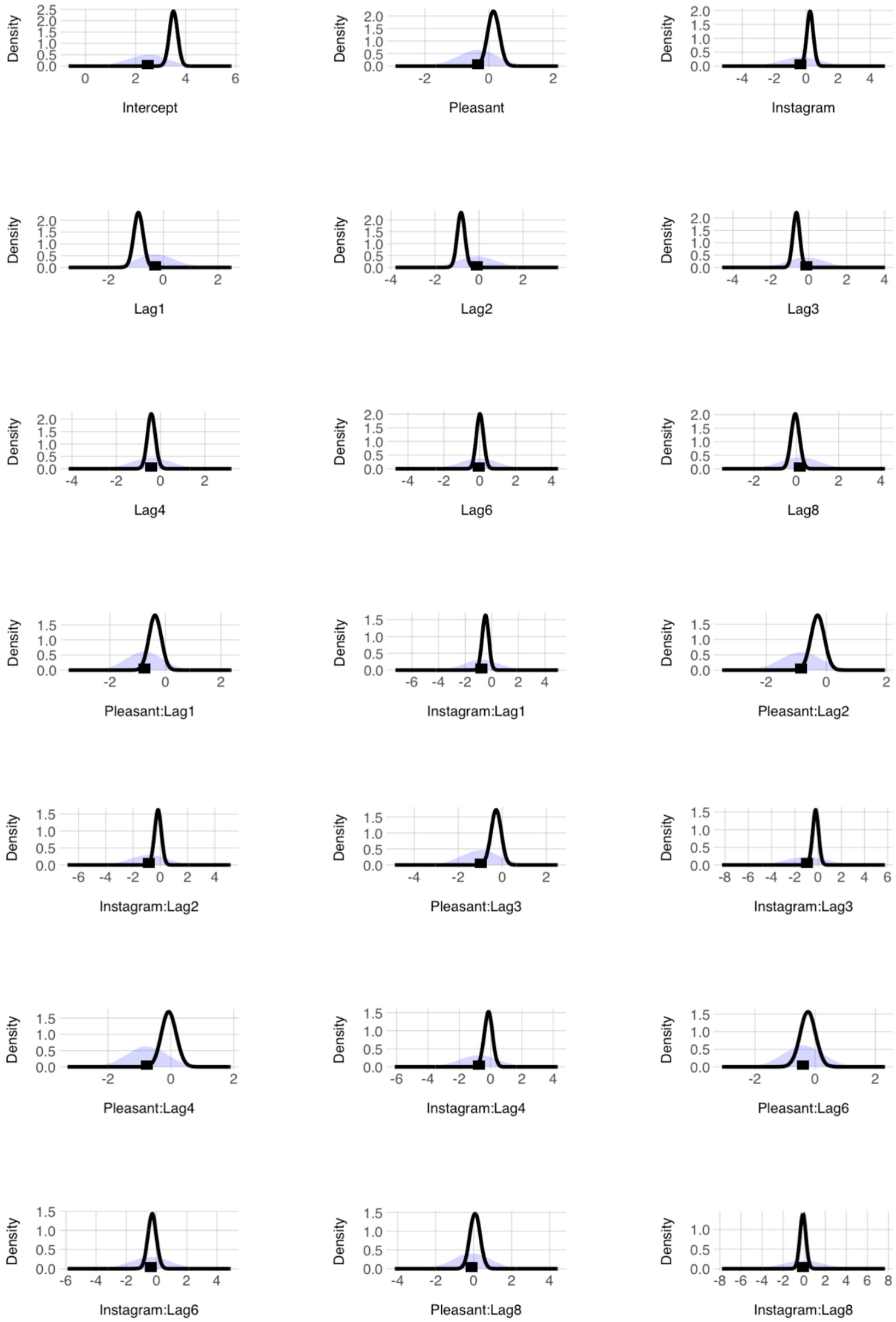
Table 7. Bayes factors' interpretation as presented in Jeffreys (1961).

Bayes Factor	*Interpretation*
$BF = 1$	No Evidence
$1 < BF < 3$	Anecdotal
$3 < BF < 10$	Moderate
$10 < BF < 30$	Strong
$30 < BF < 100$	Very Strong
$BF > 100$	Extreme

For the model containing only the three main effects of category, lag, and BSMAS-I, ΔWAIC = -32.7 compared to the model specified with the hypothesized three-way interaction. According to the computed Bayes factors, there is extremely strong evidence in favor of the absence of a three-way category × lag × BSMAS-I interaction effect (BF = 7.8 ×

10^{12}). Posterior distributions superimposed on the priors for the two-way interaction model are presented in Figure 8, and it is evident in the figure that the posterior distributions corresponding to the interaction effects are shifted more toward zero than the prior distributions.

Figure 8. Posterior distributions of the two-way interaction model superimposed on the model priors. The square points represent the center of the prior distribution for each parameter.



As is the common trend, when comparing the two best candidate models, one with two main effects of category and lag and another with three main effects of category, lag, and BSMAS-I, ΔWAIC = 0, showing no favor to either model. However, a model comparison using Bayes factors reveals anecdotal evidence in favor of the presence of the main effect of BSMAS-I (BF = 1.05).

According to both candidate models, only the effects of lag 1, lag 2, lag 3, and lag 4 reached statistical significance. The effect of lag 1 has a greater than 99% probability of being negative (β = -1.17, 95% CI [-1.37, -.98]) and can be considered significant (< .1% in ROPE). The effect of lag 2 has a greater than 99% probability of being negative (β = -.96, 95% CI [-1.15, -.75]) and can be considered significant (< .1% in ROPE). The effect of lag 3 has a greater than 99% probability of being negative (β = -.80, 95% CI [-1.00, -.59]) and can be considered significant (< .1% in ROPE). The effect of lag 4 has a greater than 99% probability of being negative (β = -.47, 95% CI [-.68, -.25]) and can be considered significant (< .1% in ROPE).

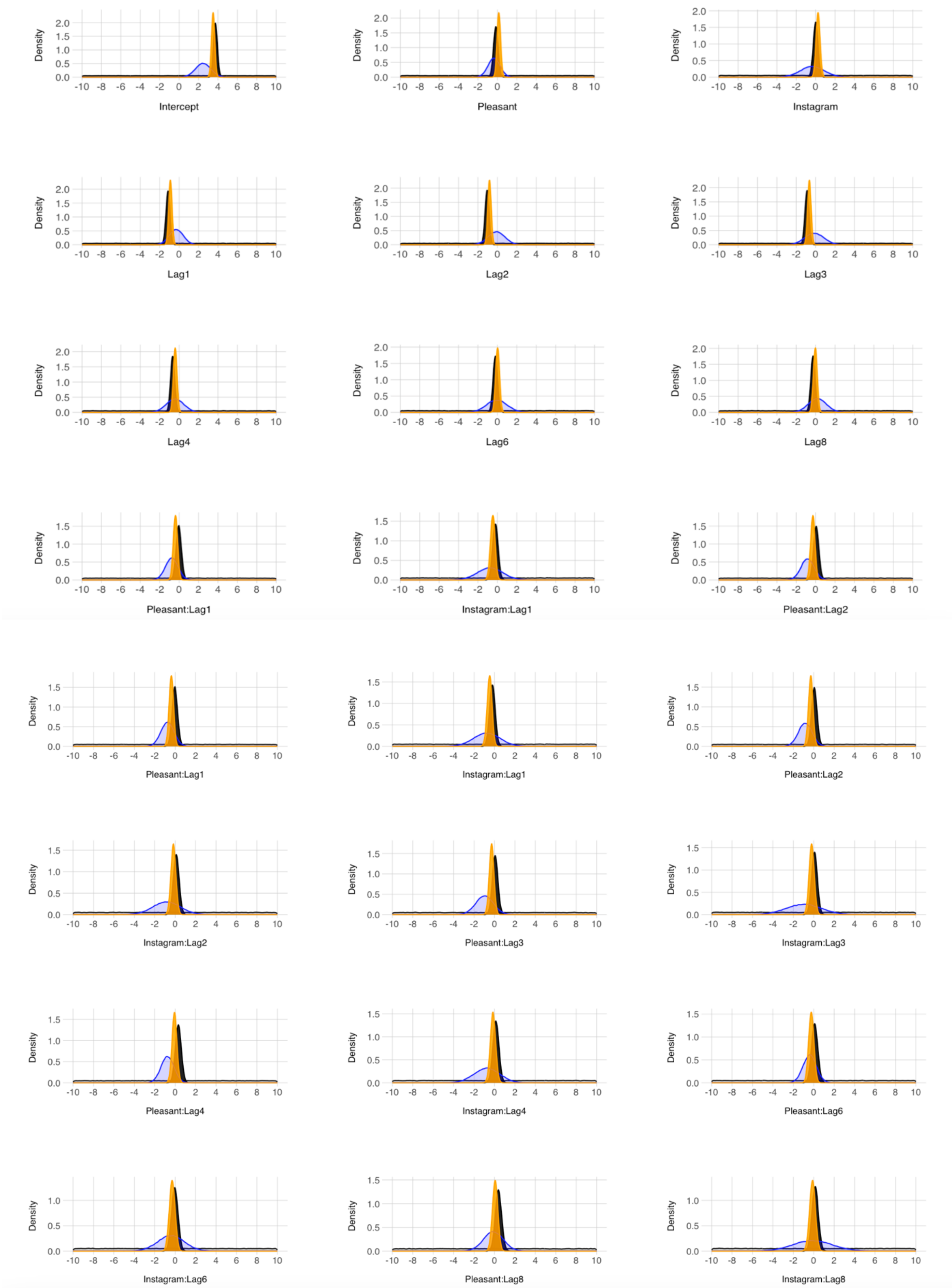
While the three-way and two-way interaction models were not the best fitting, it is worth noting that in each of these models, there were interaction effects found between category and lag at lag 1.

In the three-way interaction model, the interaction effect of category and lag at lag 1 in the pleasant condition has a greater than 95% probability of being negative (β = -.41, 95% CI [-.81, -.02]) and can be considered to have undecided significance (17.23% in ROPE). The interaction effect of category and lag at lag 1 in the Instagram condition has a greater than 95% probability of being negative (β = -.48, 95% CI [-.93, -.03]) and can be considered to have undecided significance (12.17% in ROPE).

There was a similar finding in the two-way interaction model. In this model, the interaction effect of category and lag at lag 1 in the Instagram condition has a greater than

98% probability of being negative (β = -.47, 95% CI [-.92, -.04]) and can be considered to have undecided significance (8.27% in ROPE).

Figure 9. Informed posterior distributions of the two-way interaction model superimposed on the model priors and on the uninformed model's posterior distribution.



Note. Blue = informed prior distribution. Black = uniformed posterior distribution. Orange = informed posterior distribution.

4.3.3 Models Using Informative and Default Priors

The models hereinafter discussed are those in which priors were set for all levels of each parameter, except those of the Instagram category, and for that of BSMAS-I, for which default priors were used. The use of default priors for the Instagram category parameters (main and interaction) was meant to reflect the lack of prior knowledge about the effect of Instagram-related images in this experimental paradigm. Results do not significantly differ from those of the models incorporating the more informed set of priors.

For the model containing the three main effects of category, lag, and BSMAS-I, ΔWAIC = -32.6 compared to the model specified with the hypothesized three-way interaction. According to the computed Bayes factors, there is extremely strong evidence in favor of the absence of a three-way category × lag × BSMAS-I interaction effect (BF = 1.84×10^9). When comparing the two best candidate models, one with two main effects of category and lag and the other with three main effects of category, lag, and BSMAS-I, ΔWAIC = -.1 in slight favor of the model that includes the main effect of BSMAS-I. A model comparison using Bayes factors reveals anecdotal evidence in favor of the presence of the main effect of BSMAS-I (BF = 1.14).

Nearly identically to the candidate models presented in the previous subsection, the effect of lag 1 has a greater than 99% probability of being negative (β = -1.17, 95% CI [-1.37, -.98]) and can be considered significant (< .1% in ROPE). The effect of lag 2 has a greater than 99% probability of being negative (β = -.95, 95% CI [-1.17, -.76]) and can be considered significant (< .1% in ROPE). The effect of lag 3 has a greater than 99% probability of being negative (β = -.80, 95% CI [-1.01, -.60]) and can be considered significant (< .1% in ROPE). The effect of lag 4 has a greater than 99% probability of being negative (β = -.46, 95% CI [-.69, -.25]) and can be considered significant (< .1% in ROPE).

Chapter 5: EEG Data Analysis and Results

5.1 Statistical Modeling

Individual linear mixed-effects models with subjects as the random intercept were conducted on mean EPN and LPP amplitudes with category (neutral, pleasant, Instagram-related), BSMAS-I, accuracy rate, DASS-21 score, and their interactions with category as fixed factors. Mean amplitude was particularly preferred over peak amplitude in order to account for the effect of the serially presented visual stimuli. The DASS-21 score was included in order to understand if differing ERP results regarding affectively pleasant images may be due to differing total levels of depression, anxiety, and stress. A generalized linear mixed-effects model was conducted to investigate any main or interaction effects of category and lag in the subsample of participants that underwent EEG recording in order to determine what lags to include for the calculation of accuracy rate. This is necessary because, if a participant answered incorrectly at a late lag such as lag 10, then it would be less likely to be due to an effect of the affective image presentation and more likely be due to an irrelevant factor such as a shift in gaze or natural human error (e.g., "zoning out"). The results mirrored those of the behavioral results for the whole sample in which there is a main effect of lag for the first four lags. Therefore, accuracy rate was calculated as the response accuracy in the first four lags only. Due to the small number of channels utilized, the data was subset depending on the dependent variable of the model such that, for mean EPN amplitudes, only data from occipital and parietal channels were included (i.e., Pz, P3/4, O1/2). For mean LPP amplitudes, only data from central and parietal channels were included (i.e., Cz, C3/4, Pz, P3/4).

For exploratory purposes, linear mixed-effects models with individual random intercepts were also conducted on mean P3 amplitude and LPP2 amplitude. The LPP2, here characterized as a positive deflection between 600 – 800 ms after stimulus onset, has heretofore not been mentioned in detail. The exploratory analysis of the LPP2 is based on findings and theoretical views that suggest that positive slow waves should be enhanced in response to affective visual inputs and that this enhancement reflects an increased allocation of perceptual processing resources to motivationally relevant stimuli (Cuthbert et al., 2000; Kok, 1997; Moretta & Buodo, 2021b; Ritter & Ruchkin, 1992; Ruchkin et al., 1988). These linear mixed-effects models were specified with the same fixed effects as the EPN and LPP models. In a final set of exploratory models, motives for Instagram use (i.e., coping, social, enhancement, and conformity) were included as fixed effects. All linear mixed-effects model residuals were checked for normality.

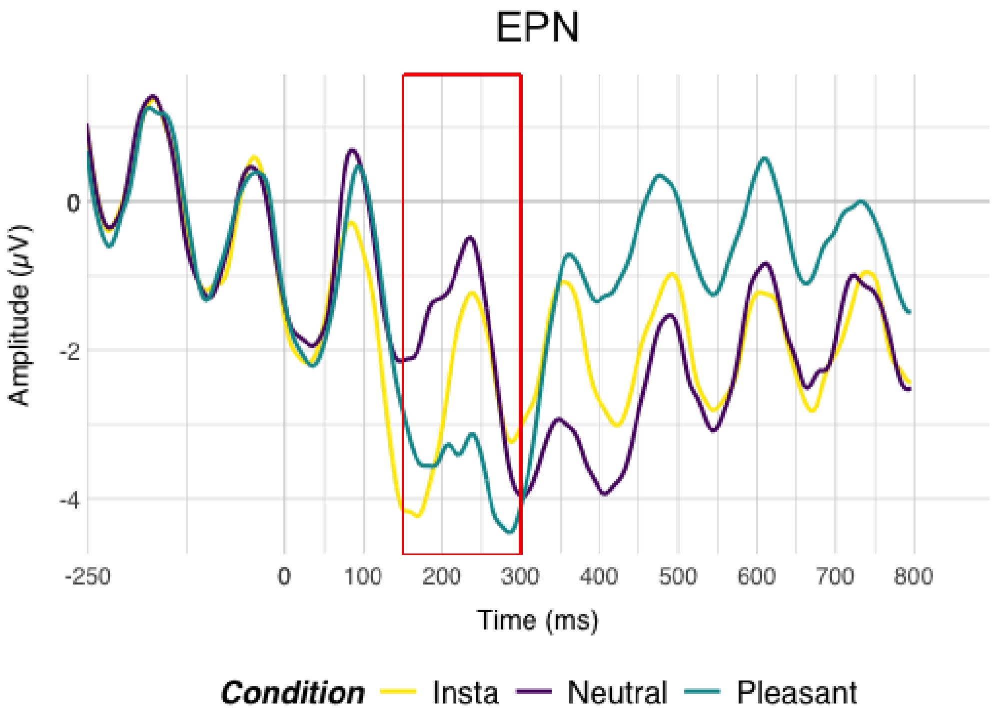
5.2 Results of EEG data

ERPs

EPN (150 – 300ms): There was a statistically significant main effect of category ($p < .001$) such that both pleasant and Instagram-related stimuli elicited larger (more negative) average EPN amplitudes compared to neutral images. No statistically significant interaction effect was found between category and BSMAS-I. There was also no interaction effect found between category and DASS-21. Lastly, there was also no main effect of accuracy rate and no interaction effect found between category and accuracy rate.

EPN post-hoc: There was no interaction effect found between category and coping nor between category and conformity. Interaction effects were statistically significant ($p < .05$) for category and social as well as for category and enhancement predicting reduced EPN in response to pleasant images. However, upon further inspection, none of the slopes characterizing these interactions were statistically significantly different from zero.

Figure 10. Waveform from occipital and parietal channels. The rectangle defines the timeframe for which average EPN amplitude was computed.



Note: Recall that the regularity of the peaks and troughs of the waveform are due to the visual stimuli's serial and continuous presentation. Therefore, visually, ERP waveforms of interest are superimposed on faster ERPs related to early stages of visual processing corresponding to initial detection and discrimination of visual stimuli. It is largely for this reason that ERP peaks were neither computed nor compared.

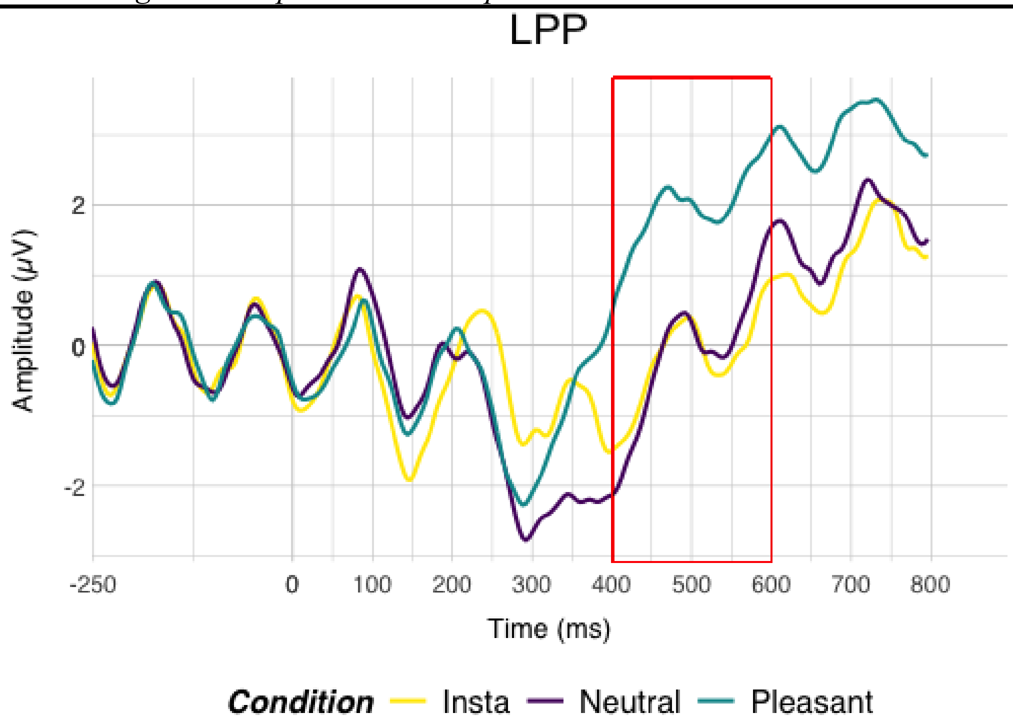
LPP (400 – 600 ms): There was a statistically significant main effect of category ($p < .001$) such that pleasant stimuli elicited larger (more positive) average LPP amplitudes compared to neutral images. Those elicited by Instagram-related stimuli were not statistically significantly different from those elicited by neutral stimuli. There was a statistically significant interaction between category and BSMAS-I ($p < .05$), although no main effect of BSMAS-I was found. In the Instagram category, a higher BSMAS-I score predicts a larger LPP. However, upon further inspection, the slope characterizing this interaction was not statistically significantly different from zero.

There was a statistically significant interaction between category and DASS-21 ($p < .05$), although no main effect of DASS-21 was found. In the pleasant category, a higher DASS-21 score predicts a larger LPP. However, upon further inspection, the slope characterizing this interaction was not statistically significantly different from zero.

There was a statistically significant main effect of response accuracy ($p < .001$) and a statistically significant interaction effect between response accuracy and category ($p < .001$). As response accuracy increases, the average LPP amplitude decreases regardless of the category of the stimulus. Moreover, that reduction in amplitude is smaller for pleasant and Instagram-related stimuli compared to neutral stimuli. Importantly, the slopes representing this interaction were all negative and statistically significantly different from zero.

LPP post hoc: There were no interaction effects between category and motives for Instagram use.

Figure 11. Waveform from central and parietal channels. The rectangle defines the timeframe for which average LPP amplitude was computed.



Post-hoc ERPs

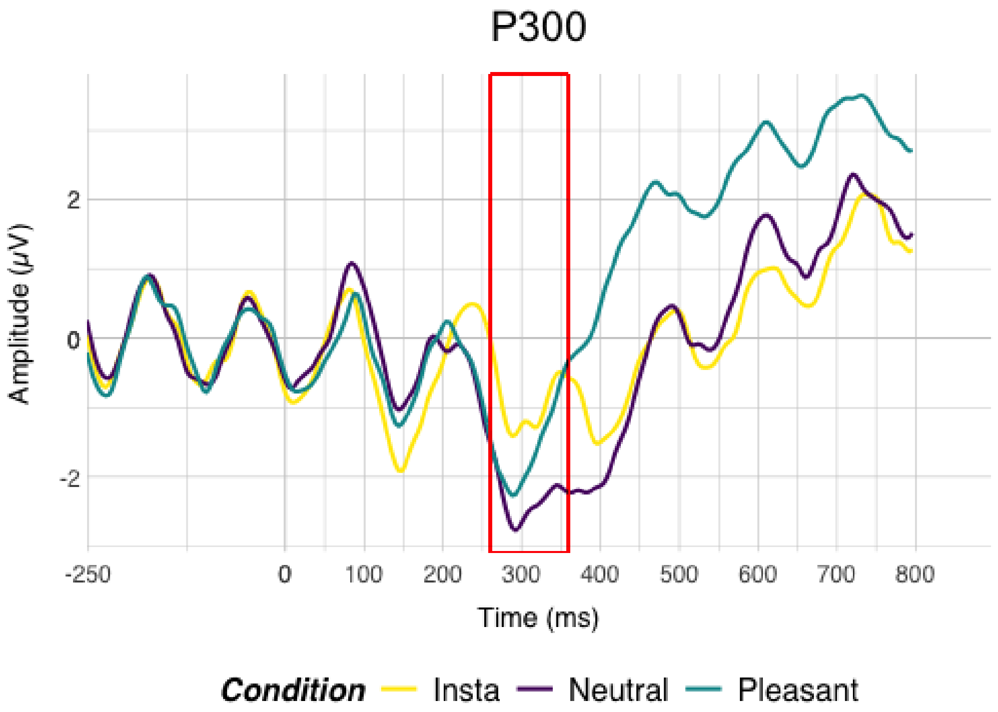
P3 (260 – 360 ms): There was a statistically significant main effect of category such that pleasant stimuli ($p < .01$) and Instagram-related stimuli ($p < .001$) elicited larger (more positive) average P3 amplitudes compared to neutral images. There was a statistically significant interaction effect of category and BSMAS-I in the Instagram category ($p < .05$), but there was no main effect of BSMAS-I. The slope representing this interaction was not statistically significant different from zero.

There was a statistically significant interaction effect of category and DASS-21 in the pleasant category ($p < .01$), but there was no main effect of DASS-21 However, the slope representing this interaction was not statistically significant different from zero.

There was a statistically significant main effect of response accuracy ($p < .01$) and a statistically significant interaction effect between category and response accuracy ($p < .01$). As response accuracy increased, the average amplitude of the P3 decreased regardless of the category of stimulus. It is possible, however that the neutral condition drives this main effect given that the interaction effect presents such that, in the pleasant and Instagram-related condition, the reduction in the average P3 amplitude is greatly attenuated. In fact, by investigating the slopes that characterize this interaction effect, it is evident that only the slope corresponding to the neutral condition is statistically significantly different from zero.

There was a statistically significant interaction effect between the pleasant category and coping ($p < .01$) indicating a larger P3 reduction in that category as the coping score increased, but the slope of the interaction effect did not statistically significantly differ from 0. Similarly, there was an interaction between category and enhancement for both pleasant and Instagram-related images, but the slopes of these interactions did not statistically significantly differ from 0. Conformity and social motives for Instagram use showed no main effects or interactions with category.

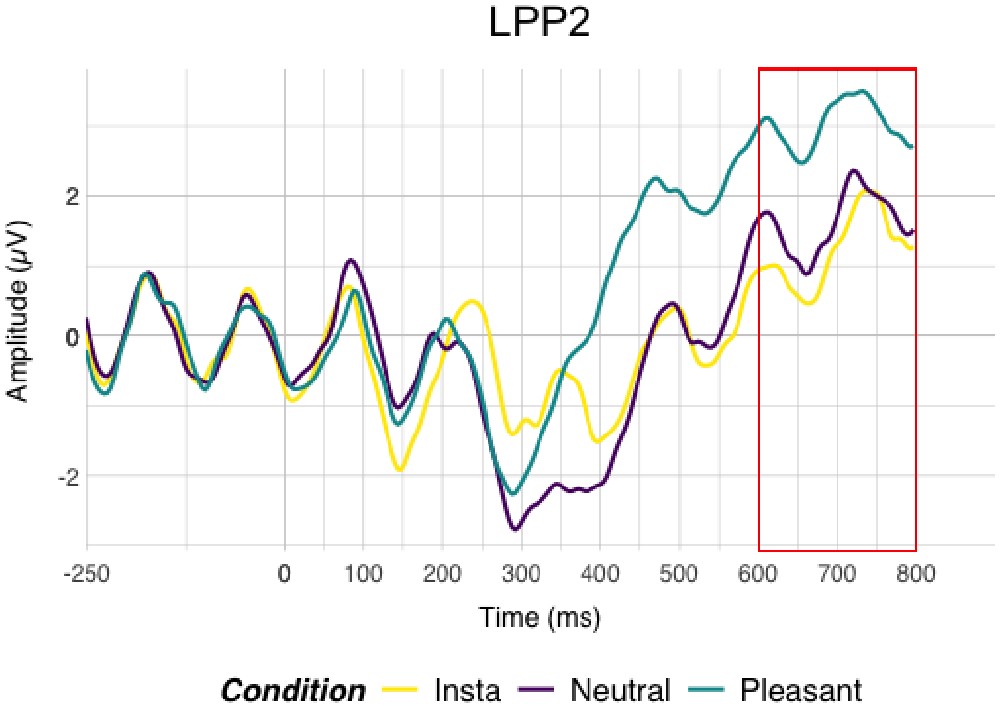
Figure 12. Waveform from central and parietal channels. The rectangle defines the timeframe for which average P3 amplitude was computed.



LPP2 (600 – 800 ms): There was a main effect of category ($p < .001$) such that pleasant stimuli elicited a larger LPP2 compared to neutral stimuli. There was no difference between the LPP2 elicited by Instagram-related and neutral stimuli. There were no main effects of BSMAS-I, DASS-21, or motives for Instagram use. Moreover, none of these variables had an interaction effect with category.

There was a statistically significant main effect of response accuracy ($p < .001$) and a statistically significant interaction effect between response accuracy and category ($p < .01$). As response accuracy increases, the average LPP2 amplitude decreases regardless of the category of the stimulus. Moreover, that reduction in amplitude is smaller for pleasant and Instagram-related stimuli compared to neutral stimuli. Importantly, the slopes representing this interaction were all negative and statistically significantly different from zero.

Figure 13. Waveform from central and parietal channels. The rectangle defines the timeframe for which average LPP2 amplitude was computed.



Chapter 6: Discussion

This study represents an effort to extend previous findings on the EAB and addiction (e.g., Olatunji et al., 2022) into the realm of PUSM. Leveraging flexible frequentist and Bayesian modeling strategies, the investigation sought to examine whether PUSM acts as a mediating factor influencing the magnitude of the EAB. Additionally, ERPs derived from EEG data were utilized to explore whether this problematic use behavior correlates with alterations in neurophysiological responses to the presentation of pleasant and Instagram-related images compared to neutral images. Through the integration of behavioral measures from the EAB task with neurophysiological data, it was possible to yield insights into the interplay between attentional processes, cue reactivity, and PUSM.

Table 8. The results of the analysis performed on behavioral data correspond to hypotheses 1 and 2 while the results of the analysis performed using physiological data from EEG recording correspond to hypotheses 3 and 4.

	Behavioral	*EEG*
H1	People who score higher on problematic Instagram use will have a more pronounced emotional attentional blink after Instagram-related stimuli compared to those who score lower, and this will be reflected in their reduced target report accuracy.	
H2	People who score higher on problematic Instagram use will have a more pronounced emotional attentional blink after pleasant stimuli compared to those who score lower, and this will be reflected in their reduced target report accuracy.	
H3		People who score higher on problematic Instagram use will have enlarged EPN and LPP components in response to images of erotica and Instagram-related images compared to those who score lower.
H4		Lower target report accuracy will correlate to an enlarged LPP component, but target report accuracy will not correlate to an enlarged EPN component.

6.1 Behavioral Data

The outcome of the statistical analyses does not support H1 or H2, which not only predict a significant interaction between category, lag, and BSMAS-I but also rely on an interaction between category in the pleasant condition and lag as a point of comparison. That is, it was expected that the EAB would be evoked with pleasant stimuli regardless of the severity of problematic Instagram use, and the strength of the EAB would be statistically distinguishable across levels of severity of problematic Instagram use. Contrary to expectation, the best-fitting models, as measured by several measures of fit (i.e., AIC, BIC, WAIC, and Bayes factors), did not incorporate these interaction terms.

6.1.1 Frequentist Approach

Testing H1 and H2 relied on the assumption that the EAB would be elicited by pleasant visual stimuli, which would be indicated by a category × lag interaction. However, the model specifying this particular interaction did not yield evidence in support of the interaction effect.

Model comparison revealed two prominent candidate models, each specified with main effects without interactions between the predictors. One of these candidates modeled the two main effects of category and lag, and the other modeled the main effects of category, lag, and BSMAS-I. Both models demonstrated superior fit relative to the null model and alternatives featuring interaction terms. The discrepancy in fit indices, particularly the slight disparity in ΔAIC and ΔBIC, renders further comparison between these two models difficult with frequentist methods. The BIC index already accounts for parsimony, and although the BSMAS-I main effect did not reach statistical significance, its explanation of variance in the dependent variable is not necessarily so negligible as to dissuade further investigations into its effect, as evidenced by a lower AIC.

The main effect of lag emerged as significant at early lags (lags 1 – 4), and this aligns with other AB and EAB studies (e.g., Santacroce et al., 2023; Grassi et al., 2021). Results indicate that when the target image is shown very quickly after the affective distractor image, the response accuracy decreases and incrementally improves as lag increases. These findings support the notion that regardless of the category of the affective image, it captured participants' attention and was likely consolidated into working memory. During this working memory consolidation process, the subsequent target could not be consolidated into working memory and therefore was not reportable when participants were then asked to select the target they saw.

Post hoc analyses revealed a main effect of BSMAS-I across lags 1 and 2, which supports the idea that higher problematic use of Instagram may predict lower response accuracy at smaller lags, regardless of the valence and/or arousal of the affective distractor image type. Given that PUSM correlates with reduced attention to the present moment (Meynadier et al., 2024), it is possible that the overall diminished response accuracy is a result of a general reduction in attentional resource allocation to the task. More meticulous research designed expressly around this hypothesis is required to make a claim that is beyond conjecture.

Post-hoc analyses also suggest that there may be an interaction effect between category and lag for Instagram-related images. These results are evidence that the shape of the EAB might be different for Instagram-related images compared to neutral or pleasant images. Graphically, the reduced width of the depressed region between lag 1 and lag 2 in Figure 4 suggests that the severity of the EAB effect is more quickly reduced for Instagram-related stimuli compared to pleasant or neutral stimuli. This "recovery" may indicate that Instagram-related stimuli may capture attention, but they do not elicit relatively sustained attention as long as other stimuli. Again, more pointed research is necessary to fully support this hypothesis and also to explore how social-media-related stimuli compare to other affective stimuli in terms of sustained attention both as a primary and secondary task.

6.1.2 Bayesian Approach

The Bayesian models' utility was especially prevalent given the ambiguity in the model comparison of the frequentist models. The models with uninformative priors, unsurprisingly, mirrored the frequentist results.

Again, the same two candidate models favored by frequentist metrics emerged as the best fitting among the uninformed Bayesian models. Neither model strongly outperformed the other, and this finding reinforced the significance of main effects over interaction effects in explaining variance in the data. Without specified priors, Bayes factors could not aid in model comparison, so these models do not offer greater insight than the frequentist models. However, they do serve as a point of reference for the Bayesian models with informed priors. In having already fit the uninformed models, it is possible to check and ensure that the informed models have leveraged the priors without strongly biasing the posteriors in the direction of the hypothesis. This is important because it rebuts the claim that by leveraging Bayesian priors at all, one is intentionally biasing the results of the analysis. Visual inspection of Figure 9 reveals that informed posteriors do no differ greatly from the uninformed posteriors.

In fact, the informed Bayesian models do not present convincing evidence differing from that of the frequentist and uninformed Bayesian models. Again, results emphasized significant negative main effects of lag at lags 1 – 4 on response accuracy. With the addition of priors, it is possible to employ Bayes factors, which in this case provide anecdotal evidence in favor of the main effect of problematic use of Instagram. This finding should be regarded with optimistic caution because no priors were available from the literature to inform the BSMAS-I parameter, so only the category and lag effects, along with their interaction terms, were informed with priors. No informed priors directly set for the BSMAS-I parameter are leveraged, meaning any significance of effect is a result of only the data of this study's sample. Taken as it is, this data with these specific analyses favor the model including BSMAS-I as a main effect. This suggests that the problematic use of Instagram does, indeed, influence target response accuracy in the EAB with neutral, pleasant, and Instagram-related stimuli. This main effect is similar to those found in previous studies on PUSM utilizing a Go-NoGo task (Goa et al., 2019; Moretta & Buodo, 2021a).

Although the more complex models underperformed compared to the simpler ones, a noteworthy finding comes from the fully informed Bayesian models respectively specifying the two and three-way interactions. In the three-way interaction model, there were two interactions of undecided significance. The first was between pleasant images and lag at lag 1. The second was between Instagram-related images and lag at lag 1. These results suggested that at lag 1, participants may be less likely to accurately report the target when the distractor affective image was pleasant or related to Instagram. The undecided significance of these interaction terms urges further research on these effects in particular. Literature supports the hypothesis in favor of the interaction effect of lag and pleasant stimuli (e.g., Keefe et al., 2019), but it is possible that the Instagram-related interaction was spurious. Future investigations may explore the possibility that social-media-related cues may evoke attentional and/or behavioral differences regardless of the level of PUSM. One such psychophysiological study has already suggested that Facebook-related cues may acquire salience in Facebook users with and without problematic use of Facebook (Moretta & Buodo, 2021b).

On the other hand, the two-way interaction model yielded a single interaction effect of undecided significance. The results of this analysis suggested that at lag 1, participants may be less likely to accurately report the target when the distractor affective image was related to Instagram. The fact that this interaction emerged in both the model accounting for BSMAS-I and the model not accounting for BSMAS-I suggests that it is a more prominent effect compared to the interaction between the pleasant condition and lag 1 in this dataset.

Regarding H1 and H2, it is not possible to draw strong conclusions regarding these hypotheses because both suppose that, at the very least, there is a category × lag interaction in the pleasant category. Because this interaction was of undecided significance, it would be irresponsible to comment with any certainty on the evidence or lack thereof for H1 and H2. However, given the data collected in this experiment, there is no evidence to support that individuals' level of problematic Instagram use influences their lag-dependent response accuracy for pleasant and Instagram-related stimuli compared to neutral stimuli in an EAB paradigm.

However, there is evidence, both from Bayesian and frequentist models, to suggest that as the level of problematic Instagram use increases, the over response accuracy decreases in an EAB paradigm with neutral, pleasant, and Instagram-related stimuli. It is difficult to say why this may be the case. It is likely not related to increased levels of depression, anxiety, or stress given that the three-way frequentist interaction model that included DASS-21 as a predictor yielded no statistically significant results.

According to the I-PACE model (Brand et al., 2019), it is possible that those with higher levels of problematic Instagram use may have impoverished executive function, such as diminished inhibitory control, which could make it more difficult to filter out irrelevant information and maintain focus on the task. Literature also suggests that PUSM is correlated to changes in the dopaminergic system (Morris et al., 2023). This dysregulation of the reward system may make it harder to sustain attention to tasks that do not provide rewards, like the EAB task. Moreover, the literature also provides a basis for the claim that those with more severe problematic Instagram use may be more attuned to social/social-media-related rewards like Likes, Comments, and algorithmically personalized content (Morris et al., 2023). This may reduce their responsiveness to non-social-media-related rewards, and this reduction might manifest as lower accuracy in attention tasks. However, whether individuals with PUSM are sensitized or have a blunted response to non-social-media-rewards is an open question in the field (Moretta & Buodo, 2021b; see also Verdejo-Garcia & Perez-Garcia, 2006).

Additionally, the lack of lag-1 sparing in this study is clear based on the large decrease in response accuracy at lag 1. Though not a focus of the present study, the lack of this phenomenon adds a small piece of evidence to a larger debate about the expected absence of lag-1 sparing in the EAB paradigm (Kennedy & Most, 2015b; MacLeod et al., 2017).

6.2 Electrophysiological Data

H3 is perhaps the more straightforward of the two hypotheses relying on electrophysiological measures. Regarding the EPN, although some research has shown that differences in EPN amplitude are not correlated to the level of PUSM (Moretta & Buodo, 2021b), this research was in a passive viewing task. However, the EPN likely reflects a process of selecting a stimulus among distractors (Bradley et al., 2007; Löw et al., 2005), so an EAB task in which the participant must select a target from an RSVP is a better paradigm to examine possible differences in EPN amplitude. On the other hand, the LPP occurs in response to arousing stimuli regardless of valence and likely reflects consolidation into working memory (Schupp et al., 2004b; Johnson, 1988; Picton, 1992; Donchin & Coles, 1988). Both the EPN and LPP may be enlarged in response to stimuli that have acquired particularly strong salience (Miltner et al., 2005, Wiens et al., 2022), and several theories of addiction suppose that increased salience is attributed to addiction-related stimuli (Robinson & Berridge, 1993; Brand et al., 2019). Some support for this supposition has been found in electrophysiological studies in which a larger LPP was elicited in substance-dependent compared to substance-dependent individuals (Dunning et al., 2011; Franken et al., 2003, 2004).

H4 is somewhat less straightforward than H3. The EPN is associated with early selection of stimuli while the LPP is associated with more sustained attention and processing of arousing stimuli. Therefore, the detection of the EPN should reflect the cognitive process of "marking" a stimulus among distractors for further processing, but this "mark" does not guarantee that the stimulus is actually encoded into working memory. Without being encoded into working memory, the target stimulus is not consciously accessible and cannot be accurately reported above chance. Because there is no guarantee that the cognitive process reflected in the EPN ensures target stimulus encoding into working memory, the EPN may not show a direct correlation to target report accuracy. It is the LPP component that is taken to reflect the encoding process of the affective stimulus, during which target stimulus is less likely to be encoded itself. In this way, the amplitude of the EPN component may not correlate to target report accuracy, but the amplitude of the LPP component may.

Despite their difference in complexity, it is H4 that is most readily supported by the results of the analysis. Conversely, interpreting the results regarding H3 requires more caution.

6.2.1 ERPs — *a priori*

Lower target report accuracy did not correlate to a change in average EPN amplitude, but lower target report accuracy did correlate to a larger average LPP amplitude. These results support the hypothesis that lower target report accuracy will correlate to an enlarged LPP component, but target report accuracy will not correlate to an enlarged EPN component (H4). Although the average LPP amplitude decreased, regardless of stimulus type, with the increase of response accuracy, the reduction in average amplitude was smaller for pleasant and

Instagram-related stimuli than it was for neutral stimuli. A possible explanation for this may be that pleasant and Instagram-related stimuli may be less readily disengaged from neutral stimuli despite this engagement's impeding the primary attentional task at hand (selecting the target stimulus). Importantly, this would not necessarily imply that the LPP amplitude is larger for these stimuli, just that they are more difficult to disengage attentional resources from compared to the neutral stimuli irrespective of the amount of attentional resources allocated.

In fact, the average LPP amplitude elicited by pleasant stimuli was larger compared to the average amplitude elicited by neutral stimuli, but the same is not true of the LPP elicited by Instagram-related stimuli, which did not differ compared to neutral stimuli. This finding differs from that of Moretta and Buodo (2021b) who found that the LPP was larger for Facebook stimuli compared to neutral stimuli. However, in Moretta and Buodo's (2021b) study, subjects participated in a passive viewing task whereas subjects in the present study were made to view affective images while engaging in a visual search task; thus, the cognitive demands of the task are quite different, so any direct comparison should be drawn with caution. In the present study, the affective images are task-irrelevant, but in the Moretta and Buodo (2021b) study, the affective images are the only stimuli with which the participant is meant to engage.

Regarding H3, there was no statistically significant interaction between the category of the affective image and BSMAS-I score on the average EPN amplitude. There was, however, a main effect of category such that pleasant and Instagram-related images elicited a larger EPN compared to neutral images. This main effect was not found in one of the few ERP studies investigating PUSM (Moretta & Buodo, 2021b), but, as already explained, the experimental paradigm is very different between this previous investigation and the current study. This main effect of category suggests that pleasant and Instagram-related images captured more attentional resources than neutral images during the visual search of the RSVP stream, regardless of the level of problematic Instagram use.

Curiously, although there was no main effect of problematic Instagram use on LPP amplitude, there was a statistically significant interaction between category and BSMAS-I. In the Instagram category, a higher BSMAS-I score predicts a larger LPP. However, the slope characterizing this interaction did not statistically significantly differ from zero. That being said, a larger sample size may help to clarify the statistical significance of the effect. It is possible that with a sample of only 29 subjects, the study is underpowered for the effect. Given the data of the present study, the hypothesis that people who score higher on problematic Instagram use will have enlarged EPN and LPP components in response to images of erotica and Instagram-related images compared to those who score lower (H3) is not supported.

Additionally, there was a statistically significant interaction between category and DASS-21 score on LPP amplitude, but there was no main effect of DASS-21. The interaction was such that a higher DASS-21 score predicted a larger LPP, but the slope characterizing this interaction was not statistically significantly different from zero, just as with BSMAS-I in the Instagram category. Again, the present study may be underpowered regarding the effect because it is likely that individuals with a higher DASS-21 score would have an altered physiological response to emotionally pleasant stimuli compared to those with a lower DASS-21 score (Proudfit et al., 2015).

6.2.2 ERPs — *post-hoc*

Post hoc analysis results suggest that those who use Instagram to increase positive feelings in themselves (enhancement motive) and in others (social motives) have a reduced average EPN amplitude in response to pleasant images compared to neutral images, but the slopes characterizing these interaction terms were not statistically significantly different from zero. The same is not true for the LPP, which had no significant interaction effects between category and any motive for Instagram use. It is unclear why there would be an association between positive valence motives across sources (internal and external) and reduced EPN amplitude in response to pleasant stimuli. Perhaps individuals motivated by increasing positive feelings develop a cognitive pattern to seek out exceptionally positive or especially novel pleasant content. This change in attentional allocation strategy may result in a reduced EPN to pleasant stimuli, but without further investigation, this is conjecture.

Graphically, the P3 component appears as the beginning of a large positive deflection that has been separated into three segments (P3, LPP, LPP2). The post-hoc analysis of the P3 was very similar to the results of analyses for the LPP component with one major difference. Both pleasant and Instagram-related stimuli elicited a larger P3 average amplitude compared to neutral images. This aligns with the behavioral results from the most informed Bayesian model, in which there was a decrease in response accuracy for target stimuli at lag 1 after Instagram-related stimuli. It also aligns with the post hoc finding from the frequentist analysis revealing a larger increase in response accuracy for the Instagram condition between lag 1 and lag 2 compared to neutral and pleasant. This cohesion of physiological and behavioral data is evident in light of the fact that later positive potentials (LPP and LPP2) do not show a statistically significant difference between the neutral and Instagram conditions. The later components are not augmented in response to Instagram-related images but the earliest positive component (P3) is, which possibly indicates that Instagram-related stimuli capture attention without eliciting relatively sustained attention or cognitive elaboration as long as other stimuli.

The LPP2 results were also largely the same as the LPP results with the exception that no interaction effects between BSMAS-I or DASS-21 score and category were found.

Whatever interaction effects that may have affected LPP amplitude seem to have disappeared by the LPP2 time window, suggesting that the severity of problematic Instagram use and general distress do not strongly influence the relatively lengthy process of emotional elaboration of affective stimuli likely reflected by the LPP2.

6.3 Limitations and Future Directions

The most obvious limitation of the present study is that the EAB was not elicited with pleasant stimuli as expected based on the literature according to the frequentist models. However, the pleasant stimuli from the IAPS (Lang, Bradley, & Cuthbert, 2008) may be simply not arousing enough to evoke a strong EAB. The erotic images from this repository used as pleasant stimuli are likely much lower in arousal level compared to the kind of erotica that is available to the general population today. Unfortunately, arousal ratings for the stimuli were not collected from each participant, so a comparison of arousal scores with the mean scores of the images from the repository was not possible. It is also possible that the images selected as neutral stimuli, in the context of their position among the images of objects used as distractors, were evaluated as relatively arousing and elicited an EAB for the neutral condition. Furthermore, it is possible that their physical distinctiveness alone was enough to produce reduced target accuracy (Santacroce et al., 2023). A replication of this study with a fourth category in which the neutral items are also common objects may clarify this point.

Repeating the study with this fourth category would also permit the creation of difference waves for a more detailed analysis of the ERP data. In the present study, difference waves were not possible because by using the neutral category as the difference waveform, the possibility of comparison to the neutral category is eliminated. Other ERP analyses may include investigating the differences in waveforms at each lag depending on whether the participant correctly or incorrectly identified the target stimulus. These analyses would likely require many more trials per lag than found in the present study in order to calculate reliable average ERPs because performance tends to be quite good in general. Some participants were incorrect on as few as one trial.

Moreover, while an international sample is favorable, the only language options offered in the study were Italian and English. The vast majority of participants who completed the study in English were not native English speakers. Participants often asked for clarification on the verbiage of certain items across the scales, so in the best-case scenario, the self-report measures of similar investigations in the future should be available in the native language of the participants.

In sum, the present study has demonstrated, with behavioral and electrophysiological data, that attentional resources may be differentially allocated to pleasant and Instagram-related stimuli compared to neutral stimuli, regardless of the severity of problematic Instagram use. Furthermore, the extent to which Instagram-related stimuli are cognitively processed may be different compared to both pleasant and neutral stimuli. This project is one of the incredibly few in which cue reactivity to social-media-related stimuli was assessed with ERP measures. To this author's knowledge, it is the only one in which cue reactivity was assessed while participants engaged in primary-task-related cognitive demands for which the affective stimuli were task-irrelevant. Though the results of the present study cannot support an argument in favor of the EAB's utility as a clinical tool, they do represent a useful basis for future research in the field of affective neuroscience and PUSM.

Works cited

Akyürek, E. G., Leszczyński, M., & Schubö, A. (2010). The temporal locus of the interaction between working memory consolidation and the attentional blink. *Psychophysiology, 47*(6), 1134–1141. https://doi.org/10.1111/j.1469-8986.2010.01033.x

Amrhein, C., Mühlberger, A., Pauli, P., & Wiedemann, G. (2004). Modulation of event-related brain potentials during affective picture processing: a complement to startle reflex and skin conductance response?. *International journal of psychophysiology : official journal of the International Organization of Psychophysiology*, *54*(3), 231–240. https://doi.org/10.1016/j.ijpsycho.2004.05.009

Anderson, A. K. (2005). Affective influences on the attentional dynamics supporting awareness. *Journal of Experimental Psychology: General, 134*(2), 258–281. https://doi.org/10.1037/0096-3445.134.2.258

Andreassen, C. S. (2015). Online social network site addiction: A comprehensive review. *Current Addiction Reports, 2*(2), 175–184. https://doi.org/10.1007/s40429-015-0056-9

Andreassen, C. S., Billieux, J., Griffiths, M. D., Kuss, D. J., Demetrovics, Z., Mazzoni, E., & Pallesen, S. (2016). The relationship between addictive use of social media and video games and symptoms of psychiatric disorders: A large-scale cross-sectional study. Psychology of Addictive Behaviors, 30(2), 252–262. https://doi.org/10.1037/adb0000160

Andreassen, C. S., & Pallesen, S. (2014). Social network site addiction - an overview. *Current Pharmaceutical Design, 20*(25), 4053–4061. https://doi.org/10.2174/13816128113199990616

Antons, S., Brand, M., & Potenza, M. N. (2020). Neurobiology of cue-reactivity, craving, and inhibitory control in non-substance addictive behaviors. *Journal of the neurological sciences*, *415*, 116952. https://doi.org/10.1016/j.jns.2020.116952

Arnell, K. M. (2006). Visual, auditory, and cross-modality dual-task costs: Electrophysiological evidence for an amodal bottleneck on working memory consolidation. *Perception & Psychophysics, 68*(3), 447–457. https://doi.org/10.3758/BF03193689

Arnell, K. M., Howe, A. E., Joanisse, M. F., & Klein, R. M. (2006). Relationships between attentional blink magnitude, RSVP target accuracy, and performance on other cognitive tasks. *Memory & cognition*, *34*(7), 1472–1483. https://doi.org/10.3758/bf03195912

Arnell, K. M., Killman, K. V., & Fijavz, D. (2007). Blinded by emotion: target misses follow attention capture by arousing distractors in RSVP. *Emotion (Washington, D.C.)*, *7*(3), 465–477. https://doi.org/10.1037/1528-3542.7.3.465

Arnell, K. M., Stokes, K. A., MacLean, M. H., & Gicante, C. (2010). Executive control processes of working memory predict attentional blink magnitude over and above storage capacity. *Psychological research*, *74*(1), 1–11. https://doi.org/10.1007/s00426-008-0200-4

Asplund, C. L., Todd, J. J., Snyder, A. P., Gilbert, C. M., & Marois, R. (2010). Surprise-induced blindness: A stimulus-driven attentional limit to conscious perception. *Journal of Experimental Psychology: Human Perception and Performance, 36*(6), 1372–1381. https://doi.org/10.1037/a0020551

Aznar-Casanova, J. A., Gavilán, J. M., Moreno Sánchez, M., & Haro, J. (2020). The Emotional Attentional Blink as a Measure of Patriotism. *The Spanish Journal of Psychology, 23*, e30. https://doi.org/10.1017/SJP.2020.32

Bargh, J.A. (1989) Conditional automaticity: varieties of automatic influence in social perception and cognition. In: Ule- man, J.S. and Bargh, J.A. (Eds.), Unintended Thought. Guilford Press, New York, pp. 3–51.

Bischof-Kastner, C., Kuntsche, E., & Wolstein, J. (2014). Identifying problematic Internet users: Development and validation of the Internet Motive Questionnaire for Adolescents (IMQ-A). Journal of Medical Internet Research, 16(10), e230. https://doi.org/10.2196/jmir.3398

Bottesi, G., Ghisi, M., Altoè, G., Conforti, E., Melli, G., & Sica, C. (2015). The Italian version of the Depression Anxiety Stress Scales-21: Factor structure and psychometric properties on community and clinical samples. *Comprehensive Psychiatry, 60*, 170–181. https://doi.org/10.1016/j.comppsych.2015.04.005

Bradley, M.M. (2000) Emotion and motivation. In: Cacioppo, J.T., Tassinary, L.G. and Berntson, G. (Eds.), Handbook of Psychophysiology. Cambridge University Press, New York, pp. 602–642.

Bradley, M. M., Codispoti, M., Cuthbert, B. N., & Lang, P. J. (2001). Emotion and motivation I: Defensive and appetitive reactions in picture processing. *Emotion, 1*(3), 276–298. https://doi.org/10.1037/1528-3542.1.3.276

Bradley, M. M., Hamby, S., Löw, A., & Lang, P. J. (2007). Brain potentials in perception: Picture complexity and emotional arousal. *Psychophysiology*, *44*(3), 364–373. https://doi.org/10.1111/j.1469-8986.2007.00520.x

Bradley, M. M., Lang, P. J., & Cuthbert, B. N. (1993). Emotion, novelty, and the startle reflex: habituation in humans. *Behavioral neuroscience*, *107*(6), 970–980. https://doi.org/10.1037//0735-7044.107.6.970

Brailovskaia, J., & Margraf, J. (2022). Addictive social media use during Covid-19 outbreak: Validation of the Bergen Social Media Addiction Scale (BSMAS) and investigation of protective factors in nine countries. Current Psychology. https://doi.org/10.1007/s12144-022-03182-z

Brand, M., Rumpf, H. J., Demetrovics, Z., Müller, A., Stark, R., King, D. L., Goudriaan, A. E., Mann, K., Trotzke, P., Fineberg, N. A., Chamberlain, S. R., Kraus, S. W., Wegmann, E., Billieux, J., & Potenza, M. N. (2020). Which conditions should be considered as disorders in the International Classification of Diseases (ICD-11) designation of "other specified disorders due to addictive behaviors"?. *Journal of behavioral addictions*, *11*(2), 150–159. Advance online publication. https://doi.org/10.1556/2006.2020.00035

Brand, M., Wegmann, E., Stark, R., Müller, A., Wölfling, K., Robbins, T. W., & Potenza, M. N. (2019). The Interaction of Person-Affect-Cognition-Execution (I-PACE) model for addictive behaviors: Update, generalization to addictive behaviors beyond internet-use disorders, and specification of the process character of addictive behaviors. *Neuroscience & Biobehavioral Reviews*, 104, 1–10. https://doi.org/10.1016/j.neubiorev.2019.06.032

Brand, M., Young, K. S., Laier, C., Wölfling, K., & Potenza, M. N. (2016). Integrating psychological and neurobiological considerations regarding the development and maintenance of specific Internet-use disorders: An Interaction of Person-Affect-Cognition-Execution (I-PACE) model. *Neuroscience & Biobehavioral Reviews*, 71, 252–266. https://doi.org/10.1016/j.neubiorev.2016.08.033

Brevers, D., Cleeremans, A., Tibboel, H., Bechara, A., Kornreich, C., Verbanck, P., & Noël, X. (2011). Reduced attentional blink for gambling-related stimuli in problem gamblers. *Journal of Behavior Therapy and Experimental Psychiatry, 42*(3), 265–269. https://doi.org/10.1016/j.jbtep.2011.01.005

Broadbent, D. E., & Broadbent, M. H. (1987). From detection to identification: response to multiple targets in rapid serial visual presentation. *Perception & psychophysics*, *42*(2), 105–113. https://doi.org/10.3758/bf03210498

Bürkner, P. C. (2017). Brms: An R package for Bayesian multilevel models using Stan. Journal of Statistical Software, 80, 1–28. https://doi.org/10.18637/jss.v080.i01

Cacioppo, J. T., Gardner, W. L., & Berntson, G. G. (1999). The affect system has parallel and integrative processing components: Form follows function. *Journal of Personality and Social Psychology, 76*(5), 839–855. https://doi.org/10.1037/0022-3514.76.5.839

Ching, A. S. M., Kim, J., & Davis, C. (2021). Time course of the unmasked attentional blink. *Psychophysiology, 58*(1), e13686. https://doi.org/10.1111/psyp.13686

Chun, M., & Potter, M. (1995). A two-stage model for multiple target detection in rapid serial visual presentation. *Journal of Experimental Psychology: Human Perception and Performance, 21*(1), 109–127. https://doi.org/10.1037/0096-1523.21.1.109

Codispoti, M., Ferrari, V., & Bradley, M. M. (2006). Repetitive picture processing: autonomic and cortical correlates. *Brain research*, *1068*(1), 213–220. https://doi.org/10.1016/j.brainres.2005.11.009

Colzato, L. S., Spapé, M., Pannebakker, M. M., & Hommel, B. (2007). Working memory and the attentional blink: blink size is predicted by individual differences in operation span. *Psychonomic bulletin & review*, *14*(6), 1051–1057. https://doi.org/10.3758/bf03193090

Cox, W. M., & Klinger, E. (1988). A motivational model of alcohol use. Journal of Abnormal Psychology, 97(2), 168–180.

Cuthbert, B. N., Schupp, H. T., Bradley, M. M., Birbaumer, N., & Lang, P. J. (2000). Brain potentials in affective picture processing: covariation with autonomic arousal and affective report. *Biological psychology*, *52*(2), 95–111. https://doi.org/10.1016/s0301-0511(99)00044-7

Cousineau, D., Charbonneau, D., & Jolicoeur, P. (2006). Parameterizing the attentional blink effect. *Canadian Journal of Experimental Psychology, 60*(3), 175-189. https://doi.org/10.1037/cjep2006017

Dell'Acqua, R., Sessa, P., Jolicoeur, P., & Robitaille, N. (2006). Spatial attention freezes during the attention blink. *Psychophysiology*, *43*(4), 394–400. https://doi.org/10.1111/j.1469-8986.2006.00411.x

Dickinson, A., & Dearing, M. F. (1979). Appetitive-aversive interactions and inhibitory processes. In A. Dickinson & R. A. Boakes (Eds.), *Mechanisms of Learning and Motivation* (pp. 203–231). Lawrence Erlbaum Associates.

Donchin E. (1981). Presidential address, 1980. Surprise!...Surprise?. *Psychophysiology*, *18*(5), 493–513. https://doi.org/10.1111/j.1469-8986.1981.tb01815.x

Donchin, E., & Coles, M. G. (1988). Is the P300 component a manifestation of context updating? *Behavioral and Brain Sciences, 11*, 357–427.

Donchin, E., Kramer, A. E., & Wickens, C. (1986). Applications of brain event-related potentials to problems in engineering psychology. In M. G. H. Coles, E. Donchin, & S. W. Porges (Eds.), *Psychophysiology: Systems, Processes, and Applications* (pp. 702–718). Guilford Press.

Dong, G., Zhou, H., & Zhao, X. (2010). Impulse inhibition in people with Internet addiction disorder: electrophysiological evidence from a Go/NoGo study. *Neuroscience letters*, *485*(2), 138–142. https://doi.org/10.1016/j.neulet.2010.09.002

Donkers, F. C., & van Boxtel, G. J. (2004). The N2 in go/no-go tasks reflects conflict monitoring not response inhibition. *Brain and cognition*, *56*(2), 165–176. https://doi.org/10.1016/j.bandc.2004.04.005

Dunning, J. P., Parvaz, M. A., Hajcak, G., Maloney, T., Alia-Klein, N., Woicik, P. A., Telang, F., Wang, G. J., Volkow, N. D., & Goldstein, R. Z. (2011). Motivated attention to cocaine and emotional cues in abstinent and current cocaine users—an ERP study. *The European Journal of Neuroscience, 22*(9), 1716–1723. https://doi.org/10.1111/j.1460-9568.2011.07663.x

Dux, P. E., & Marois, R. (2009). The attentional blink: A review of data and theory. *Attention, Perception & Psychophysics, 71*(8), 1683–1700. https://doi.org/10.3758/APP.71.8.1683

Everitt, B. J., & Robbins, T. W. (2016). Drug Addiction: Updating Actions to Habits to Compulsions Ten Years On. *Annual Review of Psychology*, 67(1), 23–50. https://doi.org/10.1146/annurev-psych-122414-033457

Franken, I. H., Hulstijn, K. P., Stam, C. J., Hendriks, V. M., & van den Brink, W. (2004). Two new neurophysiological indices of cocaine craving: evoked brain potentials and cue modulated startle reflex. *Journal of psychopharmacology (Oxford, England)*, *18*(4), 544–552. https://doi.org/10.1177/0269881104047282

Franken, I. H., Stam, C. J., Hendriks, V. M., & van den Brink, W. (2003). Neurophysiological evidence for abnormal cognitive processing of drug cues in heroin dependence. *Psychopharmacology*, *170*(2), 205–212. https://doi.org/10.1007/s00213-003-1542-7

Frijda, N. H. (1986). *The emotions.* Cambridge University Press; Editions de la Maison des Sciences de l'Homme.

Gao, Q., Jia, G., Zhao, J., & Zhang, D. (2019). Inhibitory Control in Excessive Social Networking Users: Evidence From an Event-Related Potential-Based Go-Nogo Task. *Frontiers in psychology*, *10*, 1810. https://doi.org/10.3389/fpsyg.2019.01810

Giesbrecht, B., & Di Lollo, V. (1998). Beyond the attentional blink: visual masking by object substitution. *Journal of experimental psychology. Human perception and performance*, *24*(5), 1454–1466. https://doi.org/10.1037//0096-1523.24.5.1454

Globisch, J., Hamm, A. O., Esteves, F., & Öhman, A. (1999). Fear appears fast: temporal course of startle reflex potentiation in animal fearful subjects. *Psychophysiology*, *36*(1), 66–75. https://doi.org/10.1017/s0048577299970634

Grassi, M., Crotti, C., Giofrè, D., Boedker, I., & Toffalini, E. (2021). Two replications of Raymond, Shapiro, and Arnell (1992), The Attentional Blink. *Behavior Research Methods* 53, 656–668. https://doi.org/10.3758/s13428-020-01457-6

Green, C. S., & Bavelier, D. (2003). Action video game modifies visual selective attention. *Nature*, *423*(6939), 534–537. https://doi.org/10.1038/nature01647

Griffiths, M. (2005). A ‘components’ model of addiction within a biopsychosocial framework. Journal of Substance Use, 10, 191–197.

Gutiérrez-Cobo, M. J., Luque, D., Most, S. B., Fernández-Berrocal, P., & Le Pelley, M. E. (2019). Reward and emotion influence attentional bias in rapid serial visual presentation. *Quarterly Journal of Experimental Psychology (2006), 72*(9), 2155–2167. https://doi.org/10.1177/1747021819840615

Hajcak, G., MacNamara, A., & Olvet, D. M. (2010). Event-related potentials, emotion, and emotion regulation: an integrative review. *Developmental neuropsychology*, *35*(2), 129–155. https://doi.org/10.1080/87565640903526504

Hamm, A. O., Schupp, H. T., & Weike, A. I. (2003). Motivational organization of emotions: autonomic changes, cortical responses, and reflex modulation. In R. J. Davidson, K.

Scherer, & H. H. Goldsmith (Eds.), *Handbook of Affective Sciences* (pp. 188–211). Oxford University Press.

Harris, J. A., McMahon, A. R., & Woldorff, M. G. (2013). Disruption of visual awareness during the attentional blink is reflected by selective disruption of late-stage neural processing. *Journal of Cognitive Neuroscience, 25*(11), 1863–1874. https://doi.org/10.1162/jocn_a_00443

Henry, J. D., & Crawford, J. R. (2005). The short-form version of the Depression Anxiety Stress Scales (DASS-21): Construct validity and normative data in a large non-clinical sample. *The British Journal of Clinical Psychology, 44*(Pt 2), 227–239. https://doi.org/10.1348/014466505X29657

Hoffman, J. E., Kim, M., Taylor, M., & Holiday, K. (2020). Emotional capture during emotion-induced blindness is not automatic. *Cortex*, *122*, 140–158. https://doi.org/10.1016/j.cortex.2019.03.013

Hogarth, L. (2020). Addiction is driven by excessive goal-directed drug choice under negative affect: translational critique of habit and compulsion theory. *Neuropsychopharmacology*, 45(5), 720–735. https://doi.org/10.1038/s41386-020-0600-8

Hommel, G. (1988). A Stagewise Rejective Multiple Test Procedure Based on a Modified Bonferroni Test. Biometrika, 75(2), 383–386. https://doi.org/10.2307/2336190

Huang, Y. M., Baddeley, A., & Young, A. W. (2008). Attentional capture by emotional stimuli is modulated by semantic processing. *Journal of Experimental Psychology. Human Perception and Performance, 34*(2), 328–339. https://doi.org/10.1037/0096-1523.34.2.328

Jasper, H.H. (1958) The Ten-Twenty Electrode System of the International Federation. Electroencephalography and Clinical Neurophysiology, 10, 371-375.

Jeffreys, H. (1961). Theory of Probability (3rd ed.). Oxford University Press.

Jiang, Y., & Chun, M. M. (2001). The influence of temporal selection on spatial selection and distractor interference: an attentional blink study. *Journal of experimental psychology. Human perception and performance*, *27*(3), 664–679. https://doi.org/10.1037//0096-1523.27.3.664

Johnson Jr., R. (1988) The amplitude of the P300 component of the event-related potential: review and synthesis. In: Ackles, P.K., Jennings, J.R. and Coles, M.G.H. (Eds.) Advances in Psychophysiology, Vol. 3. JAI Press, Greenwich, pp. 69–138.

Jolicœur, P., & Dell'Acqua, R. (1999). Attentional and structural constraints on visual encoding. *Psychological Research Psychologische Forschung, 62*(2), 154–164. https://doi.org/10.1007/s004260050048

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*(4), 560–578.

Jolicœur, P., Sessa, P., Dell'Acqua, R., & Robitaille, N. (2006b). On the control of visual spatial attention: evidence from human electrophysiology. *Psychological research*, *70*(6), 414–424. https://doi.org/10.1007/s00426-005-0008-4

Junghöfer, M., Bradley, M. M., Elbert, T. R., & Lang, P. J. (2001). Fleeting images: A new look at early emotion discrimination. *Psychophysiology, 38*(2), 175–178. https://doi.org/10.1017/S0048577201000762

Keefe, J.M., Sy, J.L., Tong, F., Zald, D.H. (2019). The emotional attentional blink is robust to divided attention. Attention, Perception, & Psychophysics 81, 205–216. https://doi.org/10.3758/s13414-018-1601-0

Keil, A., Bradley, M. M., Hauk, O., Rockstroh, B., Elbert, T., & Lang, P. J. (2002). Large-scale neural correlates of affective picture processing. *Psychophysiology*, *39*(5), 641–649.

Keil, A., & Ihssen, N. (2004). Identification facilitation for emotionally arousing verbs during the attentional blink. *Emotion (Washington, D.C.)*, *4*(1), 23–35. https://doi.org/10.1037/1528-3542.4.1.23

Keil, A., Ihssen, N., & Heim, S. (2006). Early cortical facilitation for emotionally arousing targets during the attentional blink. *BMC biology*, *4*, 23. https://doi.org/10.1186/1741-7007-4-23

Kennedy, B. L., & Most, S. B. (2015a). Affective stimuli capture attention regardless of categorical distinctiveness: An emotion-induced blindness study. *Visual Cognition, 23*(1–2), 105–117. https://doi.org/10.1080/13506285.2015.1024300

Kennedy, B. L., & Most, S. B. (2015b). The rapid perceptual impact of emotional distractors. *PLoS ONE, 10*(6), e0129320. doi:10.1371/journal.pone.0129320

Kennedy, B. L., Rawding, J., Most, S. B., & Hoffman, J. E. (2014). Emotion-induced blindness reflects competition at early and late processing stages: an ERP study. *Cognitive, affective & behavioral neuroscience*, *14*(4), 1485–1498. https://doi.org/10.3758/s13415-014-0303-x

Kia-Keating, M., No, U., Moore, S., Furlong, M. J., Liu, S., & You, S. (2018). Structural validity of the Depression, Anxiety, and Stress Scales-21 adapted for U.S. undergraduates. *Emerging Adulthood, 6(*6), 434–440. https://doi.org/10.1177/2167696817745407

Kok, A. (1997). Event-related-potential (ERP) reflections of mental resources: A review and synthesis. Biological Psychology, 45(1-3), 19–56. https://doi.org/10.1016/S0301-0511(96)05221-0

Konorski, J. (1967). *Integrative Activity of the Brain: An Inter-disciplinary Approach*. University of Chicago Press.

Koob, G. F., & Le Moal, M. (2008). Addiction and the Brain Antireward System. *Annual Review of Psychology*, 59(1), 29–53. https://doi.org/10.1146/annurev.psych.59.103006.093548

Lahar, C. J., Isaak, M. I., & McArthur, A. D. (2001). Age differences in the magnitude of the attentional blink. *Aging, Neuropsychology, and Cognition, 8*(2), 149–159. https://doi.org/10.1076/anec.8.2.149.842

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1990). Emotion, attention, and the startle reflex. *Psychological Review, 97*(3), 377–395. https://doi.org/10.1037/0033-295X.97.3.377

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (1997). Motivated attention: Affect, activation, and action. In P. J. Lang, R. F. Simons, & M. Balaban (Eds.), *Motivated attention: Affect, activation, and action* (pp. 97–135). Mahwah, NJ: Erlbaum.

Lang, P. J., Bradley, M. M., & Cuthbert, B. N. (2008). International affective picture system (IAPS): Affective ratings of pictures and instruction manual (Technical Report A-8).

Langher, V., Caputo, A., Giacchetta, A., Nannini, V., Sollazzo, F., Medde, P., Orsi, G., & Piccinini, N. (2019). Which affects affect the use of new technologies? Italian adaptation of the Internet Motive Questionnaire for Adolescents (IMQ-A) and criterion validity with problematic use and body dissatisfaction. Psihologija, 52(3), 217–233. https://doi.org/10.2298/psi181119003l

Littel, M., van den Berg, I., Luijten, M., van Rooij, A. J., Keemink, L., & Franken, I. H. (2012). Error processing and response inhibition in excessive computer game players: an event-related potential study. *Addiction biology*, *17*(5), 934–947. https://doi.org/10.1111/j.1369-1600.2012.00467.x

Liu, N., Li, B., Sun, N., & Ma, Y. (2008). Effects of addiction-associated and affective stimuli on the attentional blink in a sample of abstinent opiate dependent patients. *Journal of Psychopharmacology (Oxford, England), 22*(1), 64–70. https://doi.org/10.1177/0269881107077804

Lovibond, S. H., & Lovibond, P. F. (2004). *Manual for the Depression Anxiety Stress Scales, Second Edition*. Psychology Foundation.

Löw, A., Lang, P. J., & Bradley, M. M. (2005). What pops out during rapid picture presentation? [Abstract]. *Psychophysiology, 42*, S81.

Luck, S. J., & Hillyard, S. A. (1994). Electrophysiological correlates of feature analysis during visual search. *Psychophysiology*, *31*(3), 291–308. https://doi.org/10.1111/j.1469-8986.1994.tb02218.x

Luck, S. J., Vogel, E. K., & Shapiro, K. L. (1996). Word meanings can be accessed but not reported during the attentional blink. *Nature*, *383*(6601), 616–618. https://doi.org/10.1038/383616a0

MacLean, M. H., & Arnell, K. M. (2012). A conceptual and methodological framework for measuring and modulating the attentional blink. *Attention, Perception & Psychophysics, 74*(6), 1080–1097. https://doi.org/10.3758/s13414-012-0338-4

MacLeod, J., Stewart, B. M., Newman, A. J., & Arnell, K. M. (2017). Do emotion-induced blindness and the attentional blink share underlying mechanisms? An event-related potential study of emotionally-arousing words. *Cognitive, Affective & Behavioral Neuroscience, 17*(3), 592–611. https://doi.org/10.3758/s13415-017-0499-7

Maki, W. S., Frigen, K., & Paulson, K. (1997). Associative priming by targets and distractors during rapid serial visual presentation: does word meaning survive the attentional blink?. *Journal of experimental psychology. Human perception and performance*, *23*(4), 1014–1034. https://doi.org/10.1037//0096-1523.23.4.1014

Marino, C., Vieno, A., Moss, A. C., Caselli, G., Nikčević, A. V., & Spada, M. M. (2016). Personality, motives and metacognitions as predictors of problematic Facebook use in university students. *Personality and Individual Differences, 101*, 70–77. https://doi.org/10.1016/j.paid.2016.05.053

Marois, R., Yi, D. J., & Chun, M. M. (2004). The neural fate of consciously perceived and missed events in the attentional blink. *Neuron*, *41*(3), 465–472. https://doi.org/10.1016/s0896-6273(04)00012-1

Martens, S., Munneke, J., Smid, H., & Johnson, A. (2006). Quick minds don't blink: electrophysiological correlates of individual differences in attentional selection. *Journal of cognitive neuroscience*, *18*(9), 1423–1438. https://doi.org/10.1162/jocn.2006.18.9.1423

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*(6), 1275–1287.

Martens, S., & Wyble, B. (2010). The attentional blink: past, present, and future of a blind spot in perceptual awareness. *Neuroscience and biobehavioral reviews*, *34*(6), 947–957. https://doi.org/10.1016/j.neubiorev.2009.12.005

Mathewson, K. J., Arnell, K. M., & Mansfield, C. A. (2008). Capturing and holding attention: The impact of emotional words in rapid serial visual presentation. *Memory & Cognition, 36*(1), 182–200. https://doi.org/10.3758/MC.36.1.182

Mathôt, S., Schreij, D., & Theeuwes, J. (2012). OpenSesame: an open-source, graphical experiment builder for the social sciences. Behavior research methods, 44(2), 314–324. https://doi.org/10.3758/s13428-011-0168-7

Meynadier, J., Malouff, J.M., Loi, N.M, Schutte, N.S.(2024). Lower Mindfulness is Associated with Problematic Social Media Use: A Meta-Analysis. *Current Psychology 43*, 3395–3404. https://doi.org/10.1007/s12144-023-04587-0

Milders, M., Sahraie, A., Logan, S., & Donnellon, N. (2006). Awareness of faces is modulated by their emotional meaning. *Emotion (Washington, D.C.)*, *6*(1), 10–17. https://doi.org/10.1037/1528-3542.6.1.10

Miltner, W. H., Trippe, R. H., Krieschel, S., Gutberlet, I., Hecht, H., & Weiss, T. (2005). Event-related brain potentials and affective responses to threat in spider/snake-phobic and non-phobic subjects. *International journal of psychophysiology : official journal of the International Organization of Psychophysiology*, *57*(1), 43–52. https://doi.org/10.1016/j.ijpsycho.2005.01.012

Monacis, L., de Palo, V., Griffiths, M. D., & Sinatra, M. (2017). Social networking addiction, attachment style, and validation of the Italian version of the Bergen Social Media Addiction Scale. Journal of Behavioral Addictions, 6, 178–186.

Moretta, T., & Buodo, G. (2021a). Response inhibition in problematic social network sites use: an ERP study. *Cognitive, affective & behavioral neuroscience*, *21*(4), 868–880. https://doi.org/10.3758/s13415-021-00879-9

Moretta, T., & Buodo, G. (2021b). Motivated attention to stimuli related to social networking sites: A cue-reactivity study. *Journal of behavioral addictions*, *10*(2), 314–326. https://doi.org/10.1556/2006.2021.00040

Moretta T, Buodo G, Demetrovics Z, Potenza MN. Tracing 20 years of research on problematic use of the internet and social media: Theoretical models, assessment tools, and an agenda for future work. Compr Psychiatry 2022:112:152286. Available from: https://doi.org/10.1016/j.comppsych.2021.152286

Morris, R., Moretta, T., & Potenza, M. N. (2023). The Psychobiology of Problematic Use of Social Media. *Current Behavioral Neuroscience Reports.* https://doi.org/10.1007/s40473-023-00261-8

Most, S. B., Chun, M. M., Widders, D. M., & Zald, D. H. (2005). Attentional rubbernecking: cognitive control and personality in emotion-induced blindness. *Psychonomic bulletin & review*, *12*(4), 654–661. https://doi.org/10.3758/bf03196754

Most, S. B., & Jungé, J. A. (2008). Don't look back: Retroactive, dynamic costs and benefits of emotional capture. *Visual Cognition,* *16*(2-3), 262–278. https://doi.org/10.1080/13506280701490062

Most, S. B., Smith, S. D., Cooter, A. B., Levy, B. N., & Zald, D. H. (2007). The naked truth: Positive, arousing distractors impair rapid target perception. *Cognition and Emotion, 21*(5), 964–981. https://doi.org/10.1080/02699930600959340

Öhman, A., Flykt, A., & Lundqvist, D. (2000b). Unconscious emotion: evolutionary perspectives, psychophysiological data, and neuropsychological mechanisms. In R. D. Lane & L. Nadel (Eds.), *Cognitive Neuroscience of Emotion* (pp. 296–327). Oxford University Press.

Öhman, A., Hamm, A., & Hugdahl, K. (2000a). Cognition and the autonomic nervous system: orienting, anticipation, and conditioning. In J. T. Cacioppo, L. G. Tassinary,

& G. G. Bernston (Eds.), *Handbook of Psychophysiology* (2nd ed., pp. 533–575). Cambridge University Press.

Olatunji, B. O., Armstrong, T., McHugo, M., & Zald, D. H. (2013). Heightened attentional capture by threat in veterans with PTSD. *Journal of abnormal psychology*, *122*(2), 397–405. https://doi.org/10.1037/a0030440

Olatunji, B. O., Ciesielski, B. G., Armstrong, T., Zhao, M., & Zald, D. H. (2011a). Making something out of nothing: neutral content modulates attention in generalized anxiety disorder. *Depression and anxiety*, *28*(5), 427–434. https://doi.org/10.1002/da.20806

Olatunji, B. O., Ciesielski, B. G., & Zald, D. H. (2011b). A selective impairment in attentional disengagement from erotica in obsessive-compulsive disorder. *Progress in neuro-psychopharmacology & biological psychiatry*, *35*(8), 1977–1982. https://doi.org/10.1016/j.pnpbp.2011.07.005

Olatunji, B. O., Liu, Q., Zald, D. H., & Cole, D. A. (2022). Emotional induced attentional blink in trauma-exposed veterans: Associations with trauma-specific and nonspecific symptoms. *Journal of Anxiety Disorders, 87*, 102541. https://doi.org/10.1016/j.janxdis.2022.102541

Onie, S., & Most, S. B. (2021). On the relative sensitivity of spatial and nonspatial measures of attentional bias: Emotion-induced blindness, the dot probe, and gradations in ratings of negative pictures. *Emotion*. https://doi.org/10.1037/emo0000855

Palomba, D., Angrilli, A., & Mini, A. (1997). Visual evoked potentials, heart rate responses and memory to emotional pictorial stimuli. *International journal of psychophysiology : official journal of the International Organization of Psychophysiology*, *27*(1), 55–67. https://doi.org/10.1016/s0167-8760(97)00751-4

Pesciarelli, F., Kutas, M., Dell'acqua, R., Peressotti, F., Job, R., & Urbach, T. P. (2007). Semantic and repetition priming within the attentional blink: an event-related brain potential (ERP) investigation study. *Biological psychology*, *76*(1-2), 21–30. https://doi.org/10.1016/j.biopsycho.2007.05.003

Picton T. W. (1992). The P300 wave of the human event-related potential. *Journal of clinical neurophysiology : official publication of the American Electroencephalographic Society*, *9*(4), 456–479. https://doi.org/10.1097/00004691-199210000-00002

Piech, R. M., Pastorino, M. T., & Zald, D. H. (2010). All I saw was the cake. Hunger effects on attentional capture by visual food cues. *Appetite*, *54*(3), 579–582. https://doi.org/10.1016/j.appet.2009.11.003

Polich, J. (2003). Theoretical overview of P3a and P3b. In J. Polich (Ed.), *Detection of Change: Event-Related Potential and fMRI Findings* (pp. 83–98). Boston, MA: Springer US. https://doi.org/10.1007/978-1-4615-0294-4_5

Polich, J. (2007). Updating P300: An integrative theory of P3a and P3b. *Clinical Neurophysiology, 118*(10), 2128–2148. https://doi.org/10.1016/j.clinph.2007.04.019

Potter, M. C., Dell'Acqua, R., Pesciarelli, F., Job, R., Peressotti, F., & O'Connor, D. H. (2005). Bidirectional semantic priming in the attentional blink. *Psychonomic bulletin & review*, *12*(3), 460–465. https://doi.org/10.3758/bf03193788

Powell, M. J. (2009). The BOBYQA algorithm for bound constrained optimization without derivatives. Cambridge NA Report NA2009/06, University of Cambridge, Cambridge, 26, 26-46.

Proudfit, G. H., Bress, J. N., Foti, D., Kujawa, A., & Klein, D. N. (2015). Depression and Event-related Potentials: Emotional disengagement and reward insensitivity. Current opinion in psychology, 4, 110–113. https://doi.org/10.1016/j.copsyc.2014.12.018

Ptito, A., Arnell, K., Jolicœur, P., & Macleod, J. (2008). Intramodal and crossmodal processing delays in the attentional blink paradigm revealed by event-related potentials. *Psychophysiology, 45*(5), 794–803. https://doi.org/10.1111/j.1469-8986.2008.00677.x

R Core Team (2022). *R: A language and environment for statistical computing*. R Foundation for Statistical Computing, Vienna, Austria. https://www.R-project.org/

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*(3), 849–860. https://doi.org/10.1037//0096-1523.18.3.849

Ritter, W., & Ruchkin, D. S. (1992). A review of event-related potential components discovered in the context of studying P3. Annals of the New York Academy of Sciences, 658, 1–32. https://doi.org/10.1111/j.1749-6632.1992.tb22837.x

Robinson, T., & Berridge, K. (1993). The neural basis of drug craving: An incentive-sensitization theory of addiction. *Brain Research Reviews*, 18(3), 247–291. https://doi.org/10.1016/0165-0173(93)90013-p

Rolke, B., Heil, M., Streb, J., & Hennighausen, E. (2001). Missed prime words within the attentional blink evoke an N400 semantic priming effect. *Psychophysiology, 38*(2), 165–174.

Ruchkin, D. S., Johnson, R., Mahaffey, D., & Sutton, S. (1988). Toward a functional categorization of slow waves. Psychophysiology, 25(3), 339–353. https://doi.org/10.1111/j.1469-8986.1988.tb01253.x

Santacroce, L. A., Swami, A. L., & Tamber-Rosenau, B. J. (2023). More than a feeling: The emotional attentional blink relies on non-emotional "pop out," but is weak compared to the attentional blink. *Attention, Perception & Psychophysics, 85*(4), 1034–1053. https://doi.org/10.3758/s13414-023-02677-6

Shapiro, K., Driver, J., Ward, R., & Sorensen, R. E. (1997a). Priming from the attentional blink: A failure to extract visual tokens but not visual types. *Psychological Science, 8*(2), 95–100. https://doi.org/10.1111/j.1467-9280.1997.tb00689.x

Shapiro, K. L., Caldwell, J., & Sorensen, R. E. (1997b). Personal names and the attentional blink: a visual "cocktail party" effect. *Journal of experimental psychology. Human perception and performance*, *23*(2), 504–514. https://doi.org/10.1037//0096-1523.23.2.504

Schneirla, T. (1959) An evolutionary and developmental theory of biphasic processes underlying approach and withdrawal. In: Jones, M. (Ed.), Nebraska Symposium on Motivation. University of Nebraska Press, Lincoln, pp. 1–42.

Schupp, H.T., Cuthbert, B.N., Bradley, M.M., Cacioppo, J.T., Ito, T. and Lang, P.J. (2000), Affective picture processing: The late positive potential is modulated by motivational relevance. *Psychophysiology, 37*, 257-261. https://doi.org/10.1111/1469-8986.3720257

Schupp, H. T., Cuthbert, B. N., Bradley, M. M., Hillman, C. H., Hamm, A. O., & Lang, P. J. (2004b). Brain processes in emotional perception: Motivated attention. *Cognition and Emotion*, 18, 593-611. https://doi.org/10.1080/02699930341000239

Schupp, H. T., Flaisch, T., Stockburger, J., & Junghöfer, M. (2006a). Emotion and attention: event-related brain potential studies. *Progress in brain research*, *156*, 31–51. https://doi.org/10.1016/S0079-6123(06)56002-9

Schupp, H., Junghöfer, M., Weike, A. I., & Hamm, A. O. (2003a). Emotional facilitation of sensory processing in the visual cortex. *Psychological Science, 14*(1), 7–13. Retrieved from http://pss.sagepub.com/content/14/1/7.short

Schupp, H. T., Junghöfer, M., Weike, A. I., & Hamm, A. O. (2003b). Attention and emotion: an ERP analysis of facilitated emotional stimulus processing. *Neuroreport*, *14*(8), 1107–1110. https://doi.org/10.1097/00001756-200306110-00002

Schupp, H. T., Junghöfer, M., Weike, A. I., & Hamm, A. O. (2004a). The selective processing of briefly presented affective pictures: An ERP analysis. *Psychophysiology, 41*(3), 441–449. https://doi.org/10.1111/j.1469-8986.2004.00174.x

Schupp, H. T., Stockburger, J., Bublatzky, F., Junghöfer, M., Weike, A. I., & Hamm, A. O. (2003c). The selective processing of affective pictures: Effects of emotion and attention [Abstract]. *Journal of Psychophysiology, 17*, 178.

Schupp, H. T., Stockburger, J., Codispoti, M., Junghöfer, M., Weike, A. I., & Hamm, A. O. (2006b). Stimulus novelty and emotion perception: the near absence of habituation in the visual cortex. *Neuroreport*, *17*(4), 365–369. https://doi.org/10.1097/01.wnr.0000203355.88061.c6

Schwabe, L., Merz, C. J., Walter, B., Vaitl, D., Wolf, O. T., & Stark, R. (2011). Emotional modulation of the attentional blink: the neural structures involved in capturing and holding attention. *Neuropsychologia*, *49*(3), 416–425. https://doi.org/10.1016/j.neuropsychologia.2010.12.037

Schwabe, L., & Wolf, O. T. (2010). Emotional modulation of the attentional blink: is there an effect of stress?. *Emotion (Washington, D.C.)*, *10*(2), 283–288. https://doi.org/10.1037/a0017751

Seiffert, A. E., & DiLollo, V. (1997). Low-level masking in the attentional blink. *Journal of Experimental Psychology: Human Perception and Performance, 23*, 1061-1073.

Sergent, C., Baillet, S., & Dehaene, S. (2005). Timing of the brain events underlying access to consciousness during the attentional blink. *Nature neuroscience*, *8*(10), 1391–1400. https://doi.org/10.1038/nn1549

Sharbrough, F.W., Chatrian, G.E., Lesser, R.P., Lüders, H., Nuwer, M.R., & Picton, T.W. (1991). American Electroencephalographic Society Guidelines for Standard Electrode Position Nomenclature. Journal of Clinical Neurophysiology, 8, 200–202.

Singh, D., & Sunny, M. (2017). Emotion-induced blindness is more sensitive to changes in arousal as compared to valence of the emotional distractor. *Frontiers in Psychology, 8*, 1381. https://doi.org/10.3389/fpsyg.2017.01381

Slagter, H. A., Lutz, A., Greischar, L. L., Francis, A. D., Nieuwenhuis, S., Davis, J. M., & Davidson, R. J. (2007). Mental training affects distribution of limited brain resources. *PLoS biology*, *5*(6), e138. https://doi.org/10.1371/journal.pbio.0050138

Smith, Andrew, & Miles, Chris. (1986). Effects of lunch on selective and sustained attention. *Neuropsychobiology, 16*, 117-20. https://doi.org/10.1159/000118309

Stilwell, B. T., Bahle, B., & Vecera, S. P. (2019). Feature-based statistical regularities of distractors modulate attentional capture. *Journal of Experimental Psychology. Human Perception and Performance, 45*(3), 419–433. https://doi.org/10.1037/xhp0000613

Tibboel, H., De Houwer, J., & Field, M. (2010). Reduced attentional blink for alcohol-related stimuli in heavy social drinkers. *Journal of Psychopharmacology (Oxford, England), 24*(9), 1349–1356. https://doi.org/10.1177/0269881109106977

Verdejo-García, A., Pérez-García, M., & Bechara, A. (2006). Emotion, decision-making and substance dependence: a somatic-marker model of addiction. *Current neuropharmacology*, *4*(1), 17–31. https://doi.org/10.2174/157015906775203057

Visser, T. A. W., Merikle, P. M., & Di Lollo, V. (2005). Priming in the attentional blink: Perception without awareness? *Visual Cognition, 12*(7), 1362–1372.

Vogel, E. K., & Luck, S. J. (2002). Delayed working memory consolidation during the attentional blink. *Psychonomic bulletin & review*, *9*(4), 739–743. https://doi.org/10.3758/bf03196329

Vogel, E. K., Luck, S. J., & Shapiro, K. L. (1998). Electrophysiological evidence for a post-perceptual locus of suppression during the attentional blink. *Journal of Experimental Psychology: Human Perception and Performance, 24*(6), 1656–1674. https://doi.org/10.1037/0096-1523.24.6.1656

Volkow, N. D., Michaelides, M., & Baler, R. (2019). The Neuroscience of Drug Reward and Addiction. *Physiological reviews*, *99*(4), 2115–2140. https://doi.org/10.1152/physrev.00014.2018

Wang, L., Kennedy, B. L., & Most, S. B. (2012). When emotion blinds: A spatiotemporal competition account of emotion-induced blindness. *Frontiers in Psychology, 3*, 438. https://doi.org/10.3389/fpsyg.2012.00438.

Wang, L., & Most, S. B. (2011). Dissociating the impact of emotion from the impact of attentional capture on conscious perception. *Visual Cognition, 19*, 1343–1346.

Watanabe, S. (2010). Asymptotic equivalence of Bayes cross validation and widely applicable information criterion in singular learning theory. *Journal of Machine Learning Research, 11*, 3571–3594.

Weichselgartner, E., & Sperling, G. (1987). Dynamics of automatic and controlled visual attention. *Science (New York, N.Y.)*, *238*(4828), 778–780. https://doi.org/10.1126/science.3672124

Weinstein, A., & Lejoyeux, M. (2010). Internet addiction or excessive internet use. *The American journal of drug and alcohol abuse*, *36*(5), 277–283. https://doi.org/10.3109/00952990.2010.491880

Wiens, S., Eklund, R., Szychowska, M., Miloff, A., Cosme, D., Pierzchajlo, S., & Carlbring, P. (2022). Electrophysiological correlates of in vivo and virtual reality exposure therapy in spider phobia. *Psychophysiology*, *59*(12), e14117. https://doi.org/10.1111/psyp.14117

Woodman, G. F., Arita, J. T., & Luck, S. J. (2009). A cuing study of the N2pc component: an index of attentional deployment to objects rather than spatial locations. *Brain research*, *1297*, 101–111. https://doi.org/10.1016/j.brainres.2009.08.011