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# Reducing attentional capture of emotion by broadening attention: Increased global attention reduces early electrophysiological responses to negative stimuli

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## ABSTRACT

Decades of research has shown the influence of emotion on attentional capture, and more recently, the influence of emotion on neurophysiological processes related to attentional capture. The current research tested whether some of the earliest neurophysiological underpinnings of emotive attentional processes can be influenced by attentional manipulations of broadening versus narrowing. Previous research has shown that negative affects high in motivational intensity (e.g., disgust, fear) cause a relative narrowing of attentional scope (Gable and Harmon-Jones, 2010a; Easterbrook, 1959). Because of the strong link between motivation and attention, attentional scope should also influence the attentional capture of negative stimuli. The current study manipulated a local attentional scope or global attentional scope, then measured attentional capture towards disgust and neutral pictures using the N1 event-related potential component. Results revealed that a manipulated global attentional scope reduced N1 amplitude towards disgust pictures compared to a manipulated local attentional scope.

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## 1. Introduction

Over 50 years ago, Easterbrook (1959) proposed that “the innate response to a state of biological deprivation or noxious stimulation” is a reduction in the “range of cue utilization” (p. 184). Since then, numerous studies have found that attentional scope narrows following the evocation of motivationally arousing negative emotions such as fear and disgust (Chajut and Algom, 2003; Fenske and Eastwood, 2003; Gable and Harmon-Jones, 2010a; Sanders et al., 1978).

Along these lines, evidence suggests that motivationally arousing emotional stimuli influence neurophysiological responses as early as 100 ms after the onset of stimuli (Keil et al., 2001). Specifically, the N1 event-related potential (ERP) component is larger in amplitude to negative than neutral pictures (Foti et al., 2009; Keil et al., 2002; Weinberg and Hajcak, 2010). Early attentional processes as evidenced by the N1 are likely driven by several structures, including the amygdala (Olofsson et al., 2008) and anterior cingulate cortex (Esposito et al., 2009). This early modulation of the N1 by negative stimuli is proposed to be associated with motivational processes related to attentional capture (Keil et al., 2001) or more focused, detailed processing of stimuli (Vogel and Luck, 2000).

These results support the idea that stimuli that evoke motivationally arousing negative emotion narrow attention.

The present research sought to address a new question: Would a broadening of attentional scope decrease the attentional capture of motivationally arousing negative stimuli? We predicted it would. Because of the strong link between emotion and attentional scope, attentional scope may also influence emotion/motivational processes, even very early into the processing of the emotive stimuli.

Relative to a global attentional scope, a local attentional scope should increase the attentional capture of aversive pictures. Functionally, a narrowed attentional scope may enhance and allocate cognitive resources to attend on a specific object or goal. Aversive stimuli cause organisms to “zero-in”; they increase attentional focus and this focus of attention may increase motivational intensity toward the aversive object as greater cognitive resources are devoted to the object, thereby reducing the psychological distance. Along these lines, Liberman and Forster (2009) found that a manipulated narrowed attentional scope reduced the estimates of psychological distances of time, space, and social distance towards neutral objects. The enhanced cognitive processing of an object associated with a narrowed attentional scope may make the object more salient and immediate to the organism, thereby increasing the organism’s ability to react to the object.

In contrast, a broadened attentional scope may cause a reallocation of cognitive resources to attend to distal and peripheral stimuli. Broadening attentional scope may reduce the cognitive resources

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devoted to a single object and allow one to consider and think about multiple objects or goals without focusing on any particular one, thus reducing the aversive reaction to an aversive object. This may assist with disengagement from aversive stimuli and cause the organism to become open to new and previously irrelevant possibilities (Klinger, 1975).

Consistent with the idea of a bi-directional relationship between attention and emotion, past research has shown that attentional manipulations to aversive stimuli alter affective processing. However, these studies have relied on direct attentional manipulations related to the affective stimuli such as directing visual attention towards or away from affective stimuli (Dunning and Hajcak, 2009; MacNamara and Hajcak, 2009), directing reappraisal of stimuli (Foti and Hajcak, 2008; MacNamara et al., 2011; Thiruchselvam et al., 2011; Urry, 2010), manipulating the salience of stimuli (Ferrari et al., 2008; Newman et al., 2010; Schupp et al., 2007), or biasing attention towards the valence of stimuli (Dandeneau et al., 2007; Goetz et al., 2008; MacLeod et al., 2002). In other words, past studies examining attention–emotion relationships have primarily manipulated attention toward the emotional stimulus, by either increasing or decreasing attention toward the emotional stimulus. In the present research, we sought to address a different question: Does attentional scope (not the absence or presence of attention) influence emotional responses?

The current study investigated whether manipulating a broadened as compared to narrowed attentional scope would alter the attentional capture of high-withdrawal motivated negative stimuli. Specifically, we predicted that relative to a manipulated narrowed (local) attentional scope, a broadened (global) attentional scope would attenuate the attentional capture of emotional stimuli and reduce N1 amplitude.

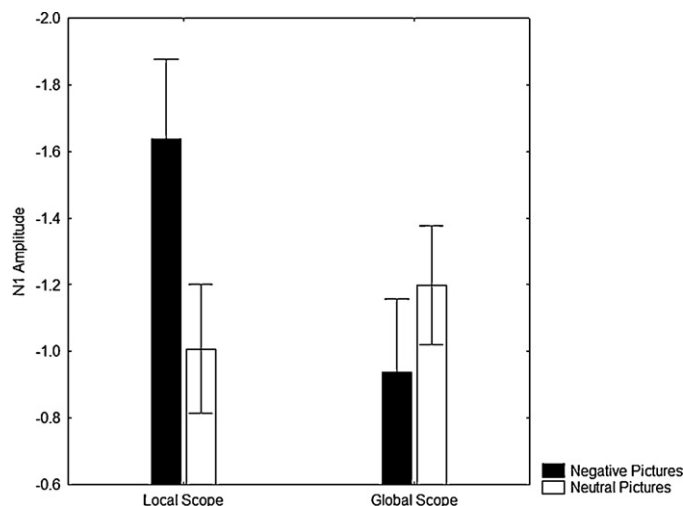
## 2. Methods

Twenty-nine (9 women) right-handed undergraduate students provided informed consent. Then, 59 EEG electrodes were applied.

Narrowed vs. broadened attentional scope was manipulated using the well-established measure of global or local attention, the Navon (1977) letters. This task has also been used extensively in research testing how affective states influence attentional scope (see review by Gable and Harmon-Jones, 2010b). A Navon letter is a large letter composed of smaller closely spaced letters (e.g., an H made of small Fs). In the current experiment, half the participants were randomly assigned to identify the small letter (i.e., local elements), and the other half were assigned to identify the large letter (i.e., global elements). Participants identified the local and global letters by pressing one of two buttons on a response box; each button was labeled with two of the four possible letters comprising the local or global figures (H and T were on one button; F and L were on the other). Responses were checked to ensure participants in both conditions correctly identified the local or global letter. One participant was excluded from analyses for missing 40% of the trials. Over all error rate was 2.3% ( $M = 1.38$ ,  $SD = 2.15$ ). Error rates did not differ between conditions,  $p > .32$ .

Participants first identified 12 practice Navon letters pictures (each was presented for 3000 ms). Then, participants viewed 64 trials (32 disgust and 32 neutral) pseudo-randomly presented such that four of one type never appeared consecutively. Each trial consisted of a fixation cross (500 ms), Navon letters figure (1500 ms), another fixation cross (3000 ms), then a disgusting or neutral picture (9000 ms). Pictures were collected from the internet and not repeated during the experiment. The neutral pictures were matched with the disgust pictures for brightness, object size, and human presence (Cronbach's alphas  $> .84$ ). Prior research using these pictures found that the disgusting pictures were rated as more unpleasant ( $M = 7.61$ ,  $SD = 1.22$ ), arousing ( $M = 6.06$ ,  $SD = 2.15$ ), and disgusting ( $M = 7.21$ ,  $SD = 2.02$ ) than the neutral pictures ( $M = 3.89$ ,  $SD = 1.22$ ;  $M = 1.67$ ,  $SD = 1.60$ ;  $M = 1.19$ ,  $SD = 0.39$ ; Gable and Harmon-Jones, 2010a).

To record EEG, 58 tin electrodes mounted in a stretch-lycra electrode cap (Electro-Cap, Eaton, OH) were used. Electro-Gel (Electro-Cap, Eaton, OH) was the conducting medium. All EEG sites were referenced online to the left earlobe; offline, data were re-referenced using the common average reference. Electrode impedances were under 5000  $\Omega$ . Signals were amplified, bandpass filtered (0.1–100 Hz; 60-Hz filter enabled), and digitized at 500 Hz using Neuroscan Synamps2 (El Paso, TX). Artifacts (e.g., aberrant signals due to muscle movement or large eye movements) were removed by hand. A regression-based eye blink correction was applied (Semlitsch et al., 1986).



**Fig. 1.** N1 amplitudes to negative and neutral pictures in a manipulated local or global attentional scope. Amplitude scores are reversed to show greater N1 amplitudes as larger.

Data were epoched for 100 ms before picture onset until 1200 ms after picture onset, and lowpass filtered at 35 Hz (Picton et al., 2000). Aggregated waveforms for each picture type were created and baseline corrected. Based on visual inspection, N1 amplitude was measured as the minimum amplitude within a window of 60–180 ms and is analogous to N1 amplitude range from comparable experiments (Gable and Harmon-Jones, 2011).<sup>1</sup> One participant from each attention manipulation condition was excluded because N1 amplitudes were greater than 2.5 SDs from the mean.

N1 amplitudes over parietal regions (P3, P1, PZ, P2, P4, PO3, POZ, PO4) were investigated, because prior research has found that the N1 to negative affective pictures is most prominent over these regions (Foti et al., 2009; for a review see Hajcak et al., 2010). In addition to the parietal N1, analogous frontal regions (FC3, FC1, FCZ, FC2, FC4, F1, FZ, F2) were investigated. No predictions were advanced for these frontal regions.

## 3. Results

A 2 (disgust or neutral picture) within-subjects  $\times$  2 (local or global target) between-subjects ANOVA revealed a significant interaction,  $F(1, 24) = 5.15$ ,  $p = .03$ ,  $\eta_p^2 = .18$  for the parietal N1 (see Fig. 1). Consistent with much past research (e.g., Foti et al., 2009; Keil et al., 2001), follow-up analyses revealed that N1s were larger to disgust pictures than to neutral pictures in the local attention manipulation condition,  $t(11) = 2.35$ ,  $p = .03$  (see Fig. 2). In other words, this local attention condition produced results identical to those obtained without an explicit manipulation of local attention (see Figs. 2 and 3; Foti et al., 2009; Keil et al., 2001), presumably because disgust pictures evoke a local bias (Gable and Harmon-Jones, 2010a). More importantly, in the global attentional manipulation condition, N1 amplitudes did not differ between disgust and neutral pictures,  $t(13) = 0.99$ ,  $p = .34$ . Comparing across the between-subjects attention manipulation conditions, N1s were larger to disgust pictures in the local attentional manipulation than in the global attentional manipulation,  $t(24) = 2.46$ ,  $p = .02$ . However, N1 amplitudes to neutral pictures were similar between conditions,  $t(24) = 0.65$ ,  $p = .52$ . N1 amplitudes did not differ as a function of attention manipulation and picture type at frontal sites,  $F(1, 24) = 0.53$ ,  $p = .47$ ,  $\eta_p^2 = .02$  (see Fig. 3).

<sup>1</sup> Previous studies have found average peak N1 amplitudes to be maximal at 100, 130, or 160 ms and used a variety of windows for peak detection (Foti et al., 2009; Keil et al., 2001, 2002; Weinberg and Hajcak, 2010). However, based on the visual inspection of our N1s, the peak amplitude appears much earlier than past studies. This could be caused by the attentional manipulation of the Navon letter which immediately preceded each picture.

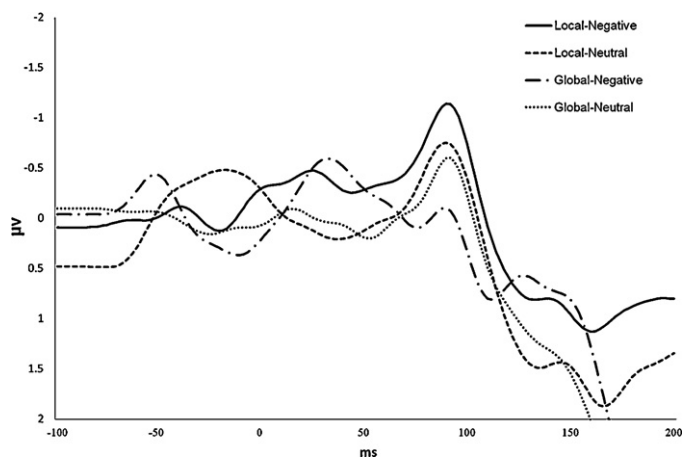


Fig. 2. N1 waveforms to negative and neutral pictures in a manipulated local or global attentional scope at midline parietal sites (PZ and POZ).

#### 4. Discussion

A manipulated global attentional scope attenuated the attentional capture of disgusting pictures compared to a manipulated local attentional scope. Attentional capture was measured using the ERP wave component N1, one of the earliest (100 ms) measures of motivated attentional processes. The manipulation of attentional scope influenced N1 responses to disgust pictures, and did not influence N1 responses to neutral pictures.

Manipulated local vs. global attentional bias was selective for enhanced motivated attention to highly aversive pictures. However, it is unlikely that these effects would occur to all negative affective stimuli, because negative affects low in motivational intensity, such as sadness, are associated with global attentional scope (Gable and Harmon-Jones, 2010a).

In addition, results of the current study are unlikely to be due specifically to negative valence. For example, our recent research shows that positive affects also vary in the degree with which they are associated with motivational intensity (Gable and

Harmon-Jones, 2008). High approach-motivated positive affects cause a narrowing of attention, whereas low approach-motivated positive affects cause a broadening of attention. Similar to the current experiment, results of Gable and Harmon-Jones (2011) suggest a bi-directional link between attentional scope and motivated attentional capture by positive stimuli. Compared to a local attentional scope, a global attentional scope attenuated attentional capture as measured by the N1 to appetitive pictures. Taken together with the present results, these results suggest that the effects of local and global attentional on N1s to emotive stimuli are due to motivational intensity and not emotional valence.

The N1 is a unique ERP component to investigating early attentional capture by emotive pictures. For example, the Early Posterior Negativity (EPN) is also modulated by attentional capture. However, the EPN tends to be more sensitive to appetitive than aversive pictures (Franken et al., 2008; Schupp et al., 2004, 2006, 2007; Weinberg and Hajcak, 2010). In addition, this component occurs later (between 200 and 300 ms) than the N1 and in a topographically different location (temporo-occipital; Foti et al., 2009). Indeed, the N1 is one of the earliest ERP components modulated by emotive processes.

Past studies examining attention–emotion relationships have primarily manipulated attention toward the emotional stimulus, by either increasing or decreasing attention toward the emotional stimulus (Dunning and Hajcak, 2009; Goetz et al., 2008; MacNamara et al., 2011; Schupp et al., 2007). In the present experiment, we demonstrated that attentional scope—as opposed to the absence or presence of attention—influenced emotional responses. In conjunction, the present and past studies further support the idea of a bi-directional relationship between attention and emotion: emotion modulates attention, and attention modulates emotion.

Attentional narrowing in high motivational states may prove adaptive. For example, in a high withdrawal negative state, a narrowed attentional scope likely assists in helping an organism to isolate and attend to a potentially dangerous object, therefore avoiding such objects. In contrast, a broadened attentional scope may cause a reallocation of cognitive resources causing one to attend to distal and peripheral stimuli. This may assist with disengagement from aversive stimuli and cause the organism to become open to new and previously irrelevant possibilities. Disengagement may prove useful when the stimuli are not actually threatening or when nothing can be done about the negative stimuli (as often happens in sadness; Gable and Harmon-Jones, 2010b). In sum, the current results suggest that relatively minor shifts in attentional scope can have significant effects on neurophysiological responses within the first 100 ms of stimulus processing, and these responses reflect motivated attention.

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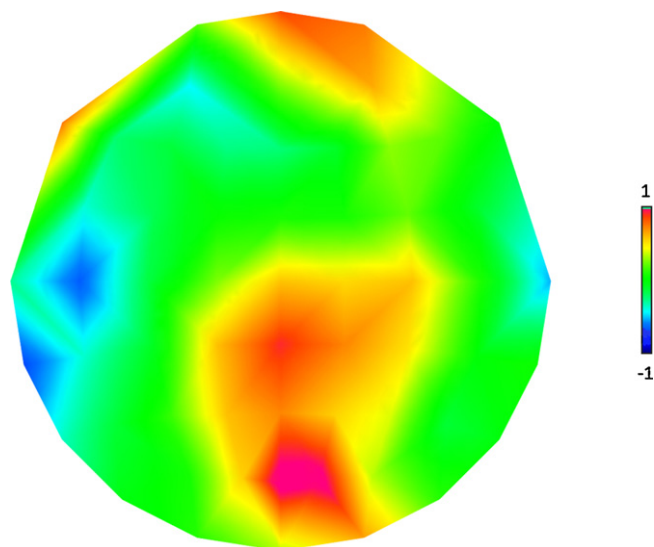


Fig. 3. Scalp distributions of the difference between neutral and disgust picture N1 amplitudes in the local condition. Positive scores (red; medial-posterior) indicate larger N1 amplitudes to disgust than neutral pictures. Because FP1 and FP2 were used as reference sites for blink correction, FP1 and FP2 sites displayed are an average of FPZ and AF3/AF4. (For interpretation of the references to color in the figure caption, the reader is referred to the web version of the article.)

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