

# In Harm's Way: On Preferential Response to Threatening Stimuli

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## Abstract

Given the evolutionary significance of survival, the mind might be particularly sensitive (in terms of strength and speed of reaction) to stimuli that pose an immediate threat to physical harm. To rectify limitations in past research, we pilot-tested stimuli to obtain images that are threatening, nonthreatening-negative, positive, or neutral. Three studies revealed that participants (a) were faster to detect a threatening than nonthreatening-negative image when each was embedded among positive or neutral images, (b) oriented their initial gaze more frequently toward threatening than nonthreatening-negative, positive, or neutral images, and (c) evidenced larger startle-eyeblinks to threatening than to nonthreatening-negative, positive, or neutral images. Social-psychological implications for the mind's sensitivity to threat are discussed.

## Keywords

evaluative processing, threat, social cognition, negativity

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Contemporary models of evaluation highlight the automatic properties of strong evaluation (e.g., Fazio & Olson, 2014; Gawronski & Bodenhausen, 2011). For example, visual attention (Roskos-Ewoldsen & Fazio, 1992) and approach-avoidance responses (Alexopoulos & Ric, 2007) engage without intent toward strongly evaluated objects. Such automaticity is ostensibly immune to attitude valence and thought to occur equivalently for positive and negative attitudes. We call such reasoning into question and propose that the mind is more sensitive to certain negatively evaluated stimuli than other negatively (or positively) evaluated stimuli. Indeed, the emotions literature demonstrates that stimuli sharing a negative evaluation can each elicit a different self-reported emotional response (e.g., anger, disgust, fear, sadness; Russell, 1980). To be clear, that emotional response is a downstream product of implicit and explicit processing (Russell & Barrett, 1999) and our concern in the current work is with early, implicit processing of stimuli. We argue that the human mind responds preferentially to threatening stimuli relative to nonthreatening stimuli. In what follows, we define threat as a peril to immediate physical harm and explain why the mind might reveal early preferential responses to such a threat. We then review evidence consistent with that possibility, highlight limitations in the evidence, and finally, present three experiments that overcome those limitations.

## Why Might the Mind Be Sensitive to Survival Threat?

By threat, we are not referring to peril to self-esteem or happiness. We are concerned with peril to immediate survival.

Hence, a threatening stimulus is one that can inflict *immediate* physical harm. Clearly, such threatening stimuli are negative. But not all negative stimuli are immediately threatening. Such things as lions, snakes, sharks, and weapons pose an imminent risk and, as we discuss subsequently, necessitate quick detection and avoidance. In contrast, other things that might be evaluated negatively, such as rotten food, dead animals, and a sick individual, do not pose an immediate survival threat requiring fast avoidance. Indeed, assessing food as rotten versus edible requires further examination and without initiating contact with a sick person the risk of harm is minimal.

A psychology of threat perception ostensibly evolved as an adaptive mechanism for the rapid avoidance of physical danger (Schaller & Neuberg, 2012). Pre-human ancestors who were faster to act when confronted with the *possibility* of threat had better odds of survival (Blanchette, 2006). This is likely why humans overestimate the threat-relevance of stimuli in ambiguous situations (Haselton & Buss, 2000; Nesse, 2005). Öhman makes the case for such an adaption in the form of a hypothetical “fear module” responsible for processing and initiating reaction to threat (Öhman, Flykt, & Esteves, 2001; Öhman & Mineka, 2001, 2003). Such processing would ostensibly utilize neural circuitry that evolved before the cortices, enabling it to function independently of (i.e., in parallel

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to) non-fear-relevant mental processes (Calder, Lawrence, & Young, 2001). Consistent with such a possibility is what LeDoux (1996, 2012) refers to as the “low road,” which is a subcortical pathway to the amygdala capable of detecting threat and activating responses without explicit processing (in contrast to the “high road,” which is slower but provides more processed—that is, cortical—information).

According to LeDoux, the amygdala may initiate responses to stimuli and activate associated processes before neocortical structures have had time to receive, interpret, and activate responses to the same information. Although the amygdala is involved in the general processing of affective and motivationally relevant information (e.g., novel, extremely positive stimuli; Cunningham & Brosch, 2012), it is particularly attuned to the initial processing of threatening information (Cunningham, Packer, Kesek, & Van Bavel, 2009). Recent neuroanatomical research in humans supports such a “low road” capable of detecting and evaluating emotionally salient information and activating associated responses without explicit awareness (Garrido, Barnes, Sahani, & Dolan, 2012; Garvert, Friston, Dolan, & Garrido, 2014; Whalen et al., 2004; cf. Pessoa & Adolphs, 2010). Hence, humans may have inherited an ability to preferentially process threat.

### Suggestive Evidence

Research provides evidence consistent with a preferential detection of and response to threat (i.e., a “threat-superiority effect”; Blanchette, 2006; Fox & Damjanovic, 2006). For example, people are quicker to detect a threatening stimulus (e.g., snake, spider) embedded among innocuous stimuli (e.g., flowers, mushrooms) than they are to detect an innocuous stimulus embedded among threatening stimuli (Öhman, Flykt, & Esteves, 2001), and are quicker to detect an angry than happy or sad face embedded among neutral faces (Eastwood, Smilek, & Merikle, 2001; Fox, Griggs, & Mouchlianitis, 2007; Öhman, Lundqvist, & Esteves, 2001). Research using continuous flash suppression (which prevents awareness of stimuli for multiple seconds) suggests that nonconscious misattribution of affect occurs for angry but not happy faces (Almeida, Pajtas, Mahon, Nakayama, & Caramazza, 2013) and threat-relevant faces emerge from suppression (i.e., enter consciousness) more quickly than do neutral or happy faces (Yang, Zald, & Blake, 2007).

Likewise, studies report different physiological responses to both supraliminally and subliminally presented threat-relevant stimuli than to either positive or neutral stimuli (Knight, Waters, & Bandettini, 2009; Morris, Öhman, & Dolan, 1998; Whalen et al., 1998). For example, subliminally presented angry faces increase skin conductance responses whereas happy faces do not (Esteves, Dimberg, & Öhman, 1994), subliminally presented fearful faces increase amygdala activity relative to happy faces (Whalen et al., 1998), supraliminally presented directly threatening stimuli elicit stronger and faster amygdala responses than do other

types of negative stimuli (Kveraga et al., 2014), and supraliminally presented threatening stimuli elicit earlier cortical activity than do other stimuli (Costa et al., 2014). Suggesting that amygdala activation to threat is independent of attention is research indicating that the amygdala shows more activity to subliminally presented fearful than neutral faces independent of fusiform facial area activity (Vuilleumier, Armony, Driver, & Dolan, 2001).

Conceptually similar perceptual and physiological patterns have been reported in studies that utilize “negative” stimuli collapsed across threatening (e.g., guns) and non-threatening-negative stimuli (e.g., dead animals, attributes such as rude). For example, people are better able to identify the presence and categorize the valence of subliminally presented negative words than either neutral or positive words (Dijksterhuis & Aarts, 2003). Likewise, subliminally presented negative but not positive stimuli potentiate startle-eyeblinks relative to neutral stimuli (Reagh & Knight, 2013) and event-related brain potentials are larger during evaluative categorization of supraliminally presented negative than positive or neutral stimuli (Ito, Larsen, Smith, & Cacioppo, 1998). Hence, extant research is consistent with the possibility that the mind is particularly sensitive to survival threats.

### The Confounding of Threat and Negativity

Although extant research implies that threat receives preferential responding, methodological limitations prevent a firm conclusion and allow the possibility that negativity, not threat per se, is the trigger. Some studies precluded a direct test by assessing reactions to threatening stimuli without additionally assessing reactions to nonthreatening-negative stimuli (e.g., Esteves et al., 1994; Öhman, Flykt, & Esteves, 2001). Other studies, as noted above, confounded threatening and nonthreatening-negative stimuli by combining them in a single stimulus set (e.g., Dijksterhuis & Aarts, 2003; Ito, Cacioppo, & Lang, 1998; Reagh & Knight, 2013). One study directly compared threatening stimuli (i.e., angry face) versus nonthreatening-negative stimuli (i.e., sad face; Öhman, Lundqvist, & Esteves, 2001), but as the authors acknowledged, the threatening stimuli were rated as more negative than the nonthreatening-negative stimuli, leaving the possibility that responses were driven by negativity, not threat. Only Kveraga et al. (2014) and Costa et al. (2014) operationally distinguished threatening from nonthreatening-negative stimuli. Though they found differential brain activity, they did not assess different attentional and behavioral responses to threatening versus nonthreatening-negative stimuli, which should occur if sensitivity to threat functions for survival. The current work provides such a test.

### The Current Work

We established with pilot-testing distinct sets of threatening, nonthreatening-negative, positive, and neutral stimuli and

conducted three studies. Each study used a different paradigm to test whether the mind responds preferentially to threatening stimuli. Study 1 used visual search to test whether threatening stimuli are detected more quickly than nonthreatening-negative stimuli. Study 2 used eye-tracking to test whether initial attention is biased to threatening stimuli than other stimuli. Study 3 used startle-eyeblick to test whether threatening stimuli elicit a stronger reflexive response than do other stimuli. For each study, we attempted to well exceed the number of participants typically recruited in each paradigm by collecting data from the beginning to end of a semester.

## Pilot Study

We conducted a pilot study to obtain stimuli that are experienced as threatening, nonthreatening-negative, positive, or neutral, respectively. We collected 400 images from public sources on the Internet, the International Affective Picture System (Lang, Bradley, & Cuthbert, 2008), the Bank of Standardized Stimuli (Brodeur, Dionne-Dostie, Montreuil, & Lepage, 2010), and images provided to us from Kveraga et al. (2014). We scaled all images to  $500 \times 500$  pixels.

One hundred forty-nine undergraduates participated for partial credit in introductory psychology. Seated in computer cubicles, they rated 400 images (presented in a random order) on one of three randomly assigned dimensions of how good ( $n = 50$ ), bad ( $n = 51$ ), or threatening ( $n = 48$ ) they deemed each image (1 = “not at all” to 7 = “extremely”).

We computed each image’s mean rating of good, bad, and threatening, and, based on those ratings, assigned each image to one of four categories: positive, neutral, nonthreatening-negative, or threatening. *Positive category* images ( $n = 94$ ) had bad and threat ratings less than 2 and good ratings greater than 5. *Neutral category* images ( $n = 92$ ) had bad and threat ratings less than 2 and good ratings less than 5. *Nonthreatening-negative category* images ( $n = 77$ ) had good ratings less than 3, bad ratings greater than 3, and threat ratings less than 4. *Threat category* images ( $n = 92$ ) had good ratings less than 3, bad ratings greater than 3, and threat ratings greater than 4. We eliminated 45 images that could not be categorized and eliminated categorized images that were (a) rendered ambiguous when scaled to  $300 \times 300$  pixels (which was necessary for Study 1), (b) natively too bright or dark to equate luminance across sets, or (c) could shift categories based on context (e.g., a plant could shift from neutral to positive if co-occurring with other positive stimuli). This yielded a final set in which the four categories were equated on luminance and red value, and contained 40 images each (see Supplemental Table 1 and Supplementary Materials).

## Study 1

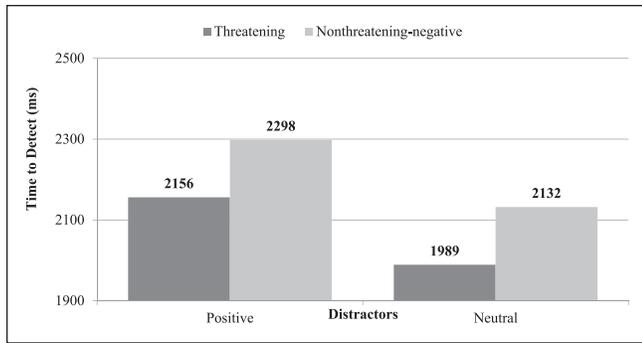
We employed a visual search paradigm (e.g., Öhman, Flykt, & Esteves, 2001; Öhman, Lundqvist, & Esteves, 2001) to test whether threatening stimuli are detected faster than

nonthreatening-negative stimuli. We compared the speed with which participants could detect a threatening stimulus embedded among all positive or neutral stimuli versus a nonthreatening-negative stimulus embedded among the same array of positive or neutral stimuli.

## Method

One hundred seven undergraduates (69 female, 38 male) participated for partial credit in introductory psychology. Participants sat in individual computer cubicles containing a 48-cm high speed, high-resolution monitor and computer. Instructions explained that the study examined attention and rapid responding, and that the participant would be presented with several trials consisting of a  $3 \times 3$  grid of eight  $300 \times 300$  pixel images surrounding a fixation point “X” in the center cell. Participants were informed that the grid would consist of pictures that were good, bad, or neutral, and that on some trials, all eight images would be of the same type (i.e., all good, all bad, or all neutral) and on other trials seven of the images would be of one type and one image would be of a different type (see Supplemental Figure 1 for an example). Their task was to indicate whether the images were all of the “same” type by pressing the Z-key or whether one of the images was of a “different” type by pressing the /-key. Each trial was heralded by a 1,000 ms center-screen fixation point (“X”), after which the grid appeared and remained until participants responded. A variable 2,000 to 6,000 ms blank screen separated each trial.

Participants completed 384 trials divided into four blocks of 96 trials, with a 1-min rest between blocks. Each block consisted of 48 congruent trials and 48 incongruent trials. Congruent trials were balanced across the four category sets. *Critical* incongruent trials within a block consisted of six trials each of one threatening image embedded among seven positive, one threatening image embedded among seven neutral, one nonthreatening-negative image embedded among seven positive, and one nonthreatening-negative image embedded among seven neutral. To ensure that the presence of threatening or nonthreatening-negative images did not serve as a cue that the stimuli were “different,” each block also included *non-critical* incongruent trials that consisted of six trials each of one positive image embedded among seven threatening, one neutral image embedded among seven threatening, one positive image embedded among seven nonthreatening-negative, and one neutral image embedded among seven nonthreatening-negative. Hence, positive, neutral, nonthreatening-negative, and threatening images were equally likely to occur on congruent and incongruent trials, and the order of congruent and incongruent trials was randomized. The image that populated each space in the matrix was fully randomized and all images from each respective category were presented before any image reoccurred. No effects were moderated by block; hence, this variable is not discussed further. Upon completion of the task, we thanked and debriefed participants.



**Figure 1.** Mean detection time as a function of target and distractor.

## Results

We excluded the responses of 15 participants due to a power outage that prematurely ended the session ( $n = 2$ ), a fire alarm during the session ( $n = 4$ ), or excessive error rates ( $> 25\%$ ) on incongruent trials ( $n = 9$ ), which yielded a sample of 92 participants (55 female, 37 male). We retained reaction times (RTs) to incongruent trials, excluded RTs for incorrect responses (9.3%), natural-log transformed RTs to adjust for excessive positive skew, and excluded transformed RTs that were 3 standard deviations above (0.68%) or below (0.43%) the mean RT. We report the results of inferential tests based on transformed data, and report descriptive statistics based on raw RTs. We computed for each participant mean RTs to the threatening and nonthreatening-negative targets embedded among the positive and neutral distractors.

We submitted RTs to a 2 (Target: threatening, nonthreatening-negative)  $\times$  2 (Distractor: positive, neutral) repeated-measures ANOVA. A main effect of distractor,  $F(1, 92) = 60.24$ ,  $p = .0001$ , indicated that participants were faster to detect a discrepancy embedded among neutral ( $M = 2,060.40$  ms,  $SD = 560.34$ ) than positive distractors ( $M = 2,226.93$ ,  $SD = 587.86$ ). More importantly, a main effect of target,  $F(1, 92) = 61.28$ ,  $p = .0001$ ,  $\eta^2 = .39$ , indicated that participants were faster to detect threatening ( $M = 2,072.55$ ,  $SD = 575.25$ ) than nonthreatening-negative stimuli ( $M = 2,214.84$ ,  $SD = 576.56$ ). This pattern was consistent across distractors as indicated by the absence of a Target  $\times$  Distractor interaction,  $F(1, 92) = .06$ ,  $p = .8019$  (Figure 1).

## Discussion

Using empirically validated stimuli, the visual search paradigm indicated that people more quickly detect a discrepant image when it is threatening than nonthreatening-negative. Although these data are consistent with the possibility that threat is found more quickly (Itti, Koch, & Niebur, 1998), the visual search paradigm has two limitations. Because the task requires participants to detect the discrepant stimulus *and* press a key signaling stimulus detection, it is possible that participants were equally likely to detect the threatening and

nonthreatening-negative stimuli but were slower to disengage from the nonthreatening-negative stimuli and press the key (West, Anderson, & Pratt, 2009). Also, the processing of threatening and nonthreatening-negative stimuli was never placed in direct competition because those stimuli did not co-occur on a given trial. Consequently, we employ a paradigm in Study 2 that overcomes both limitations to test whether threatening stimuli preferentially capture reflexive attention.

## Study 2

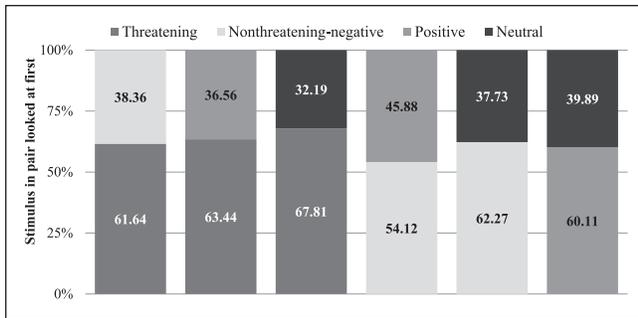
We presented participants with pairings of all four stimulus-types (e.g., a threatening image paired with a nonthreatening-negative image) and used an eye-tracker to assess the stimulus in each pair at which participants first gazed (Rayner, 1978). Because the orienting of attention in the visual field is influenced by processing goals (West et al., 2009), we created critical trials that lacked any explicit goal other than attending to the screen. If threat preferentially captures attention, initial gaze should be drawn more frequently to threatening stimuli. (As described in the Supplemental Material, we also had an exploratory interest involving gaze duration that required assessment of disgust sensitivity [Olatunji et al., 2007].)

## Method

Eighty-nine undergraduates (39 females, 50 males) participated for partial credit in introductory psychology. Participants sat in a computer cubicle ~60 cm from a 60-cm high speed, high-resolution monitor. Eye movements were recorded by a Gazepoint GP3 tracker (Gazepoint Research Inc., Vancouver, Canada) mounted below the monitor sampling at 60 Hz and captured using iMotions Biometric Research Platform (iMotions Inc., Boston, Massachusetts). A 9-point calibration was administered to ensure accurate eye-tracking (12 participants who failed to track were dismissed without completing the remaining procedure).

Instructions informed participants that the study examined the perception of motion and they would complete two tasks. For the first task, they would see a gray ball appear in the middle of the screen, move around, return to the middle, and be replaced with two still images, one to the left and one to the right of where the ball was. Participants were instructed to follow the ball with their eyes until it disappeared and simply look at the screen when the images appeared. For the second task (which never occurred), participants were told the ball would move around in front of the still images—This offered an explanation as to why there were image pairs without providing an explicit goal as to what to do with the images other than look at the screen.

Participants then completed 96 trials. Each trial began with a centrally located 2-cm gray ball that moved randomly around the screen for 4 s before returning to the center (ensuring eye gaze was centrally fixated) and disappearing,



**Figure 2.** Percent of trials a stimulus in each pairing was gazed at first.

at which point, a pair of  $500 \times 500$  pixel images appeared for 4 s. There were six types of image pairs from our four stimulus categories. Specifically, there were 16 trials each of threat with nonthreatening-negative, threat with positive, threat with neutral, nonthreatening-negative with positive, nonthreatening-negative with neutral, and positive with neutral. Images were left–right counterbalanced such that each stimulus type within a pair appeared an equal number of times on the left and right side of the screen. The image that populated the left or right side of the screen was fully randomized and all images from each respective category were presented before any image reoccurred. Participants subsequently completed the disgust sensitivity scale ( $\alpha = .86$ ; Olatunji et al., 2007), which did not moderate initial eye gaze, and were thanked and debriefed.

## Results

Of the 77 participants whose eyes tracked, 14 yielded unusable data due to software malfunction ( $n = 10$ ) or experimenter error ( $n = 4$ ), which yielded a sample of 63 (29 females, 34 males) participants with a total of 6,048 trials. We excluded 1,486 (24.57%) unusable trials because (a) less than 80% of the trial tracked ( $n = 768$ , 12.70%), (b) the trial began with the participant gazing where one of the two stimuli would appear rather than centrally fixating ( $n = 700$ , 11.57%), or (c) the participant gazed at neither stimulus during the trial ( $n = 18$ , 0.30%), thereby yielding 4,562 usable trials.

Latency to the stimulus in a given pair to which participants first gazed did not vary across the six pair-types (median = 461 ms). To test for an attentional bias toward the stimulus in each pair to which participants first gazed, we conducted a multilevel logistic regression using PROC GLIMMIX of SAS with a random intercept to control for the nested trial-by-trial gazes within participants. Initial attention was more likely to be drawn to threatening stimuli than to any other stimulus type (Figure 2). Participants first gazed at the threatening stimulus on 62% of trials when paired with a nonthreatening-negative stimulus,  $b = 0.47$ , 95% confidence interval (CI) = [0.32, 0.62],  $t(4527) = 6.05$ ,  $p = .0001$ ;

63% of trials when paired with a positive stimulus,  $b = 0.55$ , 95% CI = [0.40, 0.70],  $t(4527) = 7.02$ ,  $p = .0001$ ; and 68% of trials when paired with a neutral stimulus,  $b = 0.74$ , 95% CI = [0.58, 0.90],  $t(4527) = 9.16$ ,  $p = .0001$ . For pairs that did not involve a threatening stimulus, initial attention was more likely to be drawn to nonthreatening-negative than to positive or neutral stimuli. In particular, participants first gazed at the nonthreatening-negative stimulus on 54% of trials when paired with a positive stimulus,  $b = 0.17$ , 95% CI = [0.02, 0.31],  $t(4527) = 2.18$ ,  $p = .0292$  and 62% of trials when paired with a neutral stimulus,  $b = 0.50$ , 95% CI = [0.35, 0.65],  $t(4527) = 6.35$ ,  $p = .0001$ . Finally, initial attention was more likely to be drawn to positive than neutral stimuli with participants first gazing at the positive stimulus on 60% of trials when paired with a neutral stimulus,  $b = 0.41$ , 95% CI = [0.26, 0.56],  $t(4527) = 5.24$ ,  $p = .0001$ .

Furthermore, the tendency to first gaze at the threatening stimulus paired with a neutral or positive stimulus was stronger than the corresponding tendency to first gaze at the nonthreatening-negative stimulus. In particular, the odds of first gaze were 1.28 higher for the threatening than nonthreatening-negative stimulus when each was paired with a neutral stimulus,  $t(4527) = 2.26$ ,  $p = .0238$ , and 1.47 higher for the threatening than nonthreatening-negative stimulus when each was paired with a positive stimulus,  $t(4527) = 3.70$ ,  $p = .0002$ . Similarly, the odds of a first gaze were 1.40 higher for the threatening than positive stimulus when each was paired with a neutral stimulus,  $t(4527) = 3.11$ ,  $p = .0019$ .

## Discussion

Using empirically validated stimuli, the eye-tracking paradigm indicated that initial attention (i.e., first gaze) was most strongly drawn to threatening stimuli. Participants were more likely to gaze first at a threatening stimulus when it was paired with either a nonthreatening-negative, positive, or neutral stimulus. Furthermore, when paired with a positive or neutral stimulus, threatening stimuli drew first gaze more frequently than did a corresponding nonthreatening-negative stimulus, and the head to head pairing of threat and nonthreatening-negative directly revealed the greater attention capturing power of threat than that of nonthreatening-negativity. These patterns conceptually replicate and extend the findings from Study 1, and together suggest that threat elicits preferential response. In Study 3, we turn to a third paradigm to test whether threatening stimuli elicit uncontrolled responses more strongly than do other stimuli. In particular, we examine a response that directly captures the presumed reflexive nature of threat processing, namely startle-eyeblick (Guglielmi, 1999).

## Study 3

The startle-eyeblick paradigm utilizes a noise-blast (i.e., startle probe) to induce a blink during stimulus processing.

Facial electromyography (fEMG) measures blink amplitude by recording electrical potential generated by the orbicularis oculi muscle responsible for closing the eye (Grillon, Ameli, Woods, Merikangas, & Davis, 1991; Lang, Bradley, & Cuthbert, 1990). The eyeblink reflex is characterized by rapid contraction of the orbicularis oculi, causing a blink 30 to 50 ms after onset of a startle probe. Projections from the amygdala directly to the nucleus reticularis pontis caudalis (sensorimotor interface, located in caudal pons) influence potentiation of the startle-eyeblink reflex (Davis, 1992; Hitchcock & Davis, 1991). Evaluative information from the amygdala is carried to these brain regions, which in turn modulates startle responses (Rosen, Hitchcock, Sananes, Miserendino, & Davis, 1991). As an index of amygdala activation (i.e., underlying autonomic activation of unique evaluations), the startle response distinguishes reactions to different classes of stimuli (Amodio, Harmon-Jones, & Devine, 2003; Robinson & Vrana, 2000). This paradigm is especially appropriate to our current goal given the amygdalar role in processing information related to motivationally relevant stimuli (Davis, 1992).

The startle method has been used to discriminate responses to various types of stimuli (for review, see Bradley, Cuthbert, & Lang, 1999). Eyeblink responses are a combination of *affective* modulation and *attentional* interest effects (Filion, Dawson, & Schell, 1998; Vanman, Ryan, Pedersen, & Ito, 2013). Affective modulation reflects biphasic evaluation leading to either negative (aversive) action dispositions and startle potentiation or positive (appetitive) action disposition and no startle potentiation. Alternatively, the attentional resource framework holds that startle amplitude decreases as relative interest increases. However, these effects often co-occur; for instance, startle responses to negative objects can involve both an interest and aversive response. Negative stimuli, being evaluatively congruent with the aversive noise-blast, enhance startle responses (Lang et al., 1990), effectively overwhelming inhibition from interest. People, for example, manifest larger startle-eyeblinks when viewing negative stimuli relative to positive or neutral stimuli at long lead intervals (i.e., when the startle probe is administered > 1 s after prime onset; Amodio et al., 2003; March & Graham, 2015; Vrana, Spence, & Lang, 1988; for review, see Filion et al., 1998), even though interest in these stimuli is high. (Though it should be noted that these negative stimuli confounded threat and negativity.) Conversely, positive stimuli are evaluatively incongruent with the subsequent probe, and because only attention is influencing startle responses absent aversion, the startle reflex is inhibited (Filion et al., 1998; Vanman et al., 2013). People, therefore, exhibit weaker startle-eyeblinks when viewing positive relative to negative or neutral stimuli at long lead intervals (Dillon & LaBar, 2005).

Although it has been suggested that startle-eyeblink discriminates between positive and negative stimuli, as discussed previously, research has not systematically disentangled the impact of threatening versus nonthreatening-negative stimuli. Given

results from Studies 1 and 2, we expect threatening stimuli to enhance startle-eyeblinks relative to nonthreatening-negative, positive, or neutral stimuli. When threat is removed from negativity, given the attentional effects just mentioned, it is unclear what impact nonthreatening-negative stimuli will have on startle-eyeblinks relative to positive or neutral stimuli.

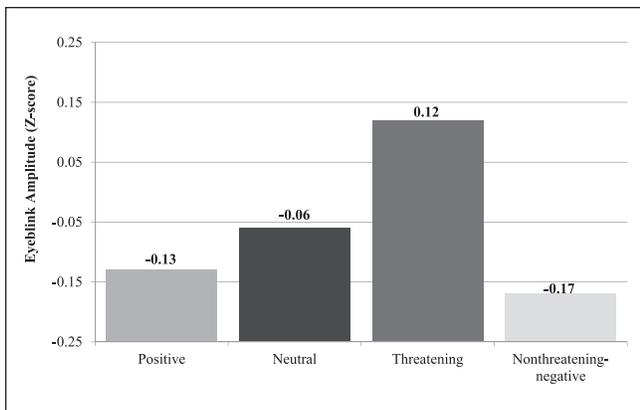
## Method

One hundred fifty-five undergraduates (116 females, 37 males, 2 unspecified) participated for partial credit in introductory psychology. Participants were seated in a cubicle ~75 cm from a 60-cm monitor, affixed with stereo headphones, and screened for normal or corrected-to-normal vision, hearing, and acoustic sensitivity. Skin was lightly abraded and cleaned with alcohol to ensure proper impedance. Then 4-mm Ag-AgCl electrodes were placed ~20 mm apart over the orbicularis oculi muscle below the left eye, with a forehead ground (Blumenthal et al., 2005). EMG data were acquired with a BioPac MP36 amplifier and AcqKnowledge 4.1 software (Biopac, Goleta, California) at a rate of 2000 Hz, amplified with a gain of 5000, and notch (60 Hz) and band-pass filtered (HP = 10 Hz, LP = 500 Hz) online. Additional stop (57-63 Hz) and band-pass (HP = 28 Hz, LP = 500 Hz) filters were applied offline. Raw EMG data were rectified, fully integrated, and averaged over 20 samples with the root mean square.

Instructions explained that participants would view various images and occasionally hear a loud noise, with their task being to look at the images. Before the critical task, participants sampled the noise-blast—a 50 ms binaural burst of 1000 Hz, 100 dB white noise (headphones were calibrated daily with a decibel meter). Participants subsequently completed 112 trials. Each trial began with a 1,000 ms presentation of a centrally located fixation “X” followed by a 6,000 ms presentation of a centrally located 500 × 500 pixel image, which was followed by an 8,000 to 12,000 ms between-trial blank screen. Twenty-eight trials apiece were positive, neutral, nonthreatening-negative, or threatening. The image that appeared was fully randomized and no images reoccurred. On 32 critical trials (eight of each image type), the noise-probe sounded 2,000 to 4,000 ms after image onset. Probes also sounded during the blank screen between 16 trials. Presentation order of image types and occurrence of probes were fully randomized. This presentation pattern was utilized to mitigate the influence of control (i.e., predictability) and maximize the likelihood of engaging in affective processes (Amodio et al., 2003; Robinson & Vrana, 2000). Participants were subsequently debriefed and thanked.

## Results

Thirty-one participants provided unusable data: 19 were nonresponders (i.e., did not blink in response to the noise); eight cringed excessively, thereby impeding assessment of



**Figure 3.** Mean standardized eyeblink amplitude as a function of image type.

eyeblink amplitude; and four requested to end the study early, which yielded a sample of 124 participants (94 females, 28 males, two unspecified) with a total of 3,965 critical trials (one session terminated unexpectedly after the participant was exposed to 29 of the 32 critical trials).

Startle-eyeblink amplitude to a given trial was calculated by subtracting the mean fEMG amplitude across the 50 ms baseline-period preceding the probe from the maximum amplitude achieved during the 200 ms period following probe onset. Occasional trials are unusable (Blumenthal et al., 2005), and we excluded 574 trials across participants (14.47% of all trials) due to the absence of a blink ( $n = 257$ ), blink during baseline ( $n = 161$ ), or excessive orbicularis oculi movement during the trial ( $n = 156$ ). Exclusion was unrelated to image type,  $\chi^2(3) = 1.99$ ,  $p = .5726$ . To control for substantial between-person variation in baseline and blink fEMG levels, startle-eyeblink amplitudes were standardized within person (Blumenthal et al., 2005). After standardization, we excluded amplitudes that varied by at least 2.5 standard deviations from the person-mean ( $n = 70$ ) and exclusion was unrelated to image type,  $\chi^2(3) = 3.18$ ,  $p = .3642$ . Examination of the 3,321 usable trials revealed eight participants who had responses on 50% or fewer of critical trials. Conclusions (based on direction of effects and  $p$  values) are the same with or without those eight participants, and we report results that include those participants.

We computed for each participant mean startle-eyeblink amplitude to each of the four stimuli types (positive, neutral, nonthreatening-negative, threatening) and submitted them to a repeated-measures ANOVA. A significant stimulus effect,  $F(3, 121) = 10.83$ ,  $p = .0001$ , indicated that amplitudes varied as a function of stimulus type. Consistent with predictions, threatening stimuli elicited a stronger startle response than did any other stimulus type (see Figure 3). In particular, startle-eyeblink amplitude was larger to threatening stimuli than to nonthreatening-negative,  $F(1, 123) = 29.86$ ,  $p = .0001$ ,  $\eta^2 = .20$ ; neutral,  $F(1, 123) = 9.72$ ,  $p = .0023$ ,  $\eta^2 = .07$ ;

or positive,  $F(1, 123) = 21.24$ ,  $p = .0001$ ,  $\eta^2 = .15$ , stimuli. Furthermore, startle-eyeblink amplitude to nonthreatening-negative stimuli was smaller than it was to neutral stimuli,  $F(1, 123) = 4.05$ ,  $p = .0465$ ,  $\eta^2 = .03$ , and equivalent to positive stimuli,  $F(1, 123) = 0.67$ ,  $p = .4130$ ,  $\eta^2 = .01$ . There was no difference in eyeblink amplitude to neutral and positive stimuli,  $F(1, 123) = 2.36$ ,  $p = .1270$ ,  $\eta^2 = .02$ .

## Discussion

Using empirically validated stimuli, the startle paradigm indicated that threatening stimuli elicited a stronger reflexive startle response than did nonthreatening-negative, positive, and neutral stimuli. These data converge with those of Studies 1 and 2 and point to a sensitivity to threat that is distinct from nonthreatening-negativity. Also noteworthy is that when threat was removed from negativity, the nonthreatening-negative stimuli produced a *weaker* startle-eyeblink than did neutral stimuli. This weaker response makes sense given the argument that aversive affect and prolonged attention differentially influence startle with aversion enhancing startle (Lang et al., 1990) and attention inhibiting startle (Filion et al., 1998; Vanman et al., 2013). Negative stimuli lacking in threat might evoke morbid fascination (Kveraga et al., 2014; Oosterwijk, Lindquist, Adebayo, & Barrett, 2015) or what could be construed as a temporary approach motivation (i.e., increased attention) to determine whether avoidance is necessary (Rimé, Delfosse, & Corsini, 2005; Rubenking & Lang, 2014; Turner & Silvia, 2006). The interested reader should see the Supplemental Material for further discussion and exploratory analysis of this morbid fascination possibility.

## General Discussion

We examined the possibility that the mind is particularly sensitive to immediate threats to bodily harm. To rectify limitations of past research, we pilot-tested stimuli to obtain images that are threatening, nonthreatening-negative, positive, or neutral, and employed three paradigms assessing differential responses to those stimuli. Participants (a) were faster to detect a threatening than nonthreatening-negative stimulus when each was embedded among positive or neutral stimuli; (b) oriented their initial gaze more frequently to threatening than nonthreatening-negative, positive, or neutral stimuli; and (c) evidenced larger startle-eyeblinks to threatening than to nonthreatening-negative, positive, or neutral stimuli. These data indicate that threat elicits preferential responses in terms of fast detection, initial attention, and reflexive responding. The mind's apparent sensitivity to threatening stimuli has an important implication for social-psychological approaches to evaluative processing. Before elaborating on that implication, however, we first consider issues regarding our stimulus categories.

### Is the Threat Effect Driven by a Facet of Nonthreatening-Negativity?

Our thesis is that because survival requires rapid response to threats to immediate physical harm, the mind should have evolved a preferential sensitivity to such threats (e.g., Öhman & Mineka, 2001, 2003). Consequently, we created stimulus categories that differentiated threatening stimuli from nonthreatening-negative stimuli (as well as positive and neutral stimuli). The curious reader might question whether our nonthreatening-negative stimuli could be further subdivided and whether any of those divisions yield different response patterns in regard to threat. To explore this possibility, we further categorized the nonthreatening-negative stimuli into systematic groupings. Visual inspection (see Supplemental Material) revealed two categories: (a) dead/injured animals and (b) repulsive objects (e.g., maggots, excrement, vomit, decayed teeth). This categorization maps onto Mikels et al.'s (2005) analysis with dead/injured animals eliciting self-reported sadness and disgust, and repulsive objects eliciting disgust.

We reanalyzed each study to determine whether the preferential response to threatening stimuli was unique to one category of nonthreatening-negative stimuli. In Study 1, participants were faster to detect the threatening stimuli ( $M = 2,072.55$  ms) than either dead animals ( $M = 2,211.49$  ms),  $F(1, 92) = 40.40, p < .0001$ , or repulsive object ( $M = 2,236.45$  ms),  $F(1, 92) = 44.28, p < .0001$ , and the latter two did not differ,  $F(1, 92) = .03, p = .8730$ . In Study 2, participants first gazed at the threatening stimulus on 59% of trials when paired with a dead animal,  $t(4524) = 3.35, p = .0008$ , and on 64% of the trials when paired with a repulsive object,  $t(4524) = 5.37, p < .0001$ , and those odds did not differ,  $t(4524) = -1.45, p = .1461$ , odds ratio (OR) = .81. In Study 3, startle-eyeblick amplitude was stronger to threats ( $M = .12$ ) than either dead animals ( $M = -.20$ ),  $F(1, 118) = 33.22, p < .0001$ , or repulsive objects ( $M = -.18$ ),  $F(1, 118) = 18.39, p < .0001$ , and the latter two did not differ,  $F(1, 118) = .21, p = .6447$ . Hence, the preferential response (fast detection, initial attention, reflexive response) to threatening stimuli was not driven by a particular facet of our nonthreatening-negative stimuli and occurred in regard to both categories of nonthreatening-negative stimuli.

For the sake of clarity, it should be emphasized that a sensitivity to threatening stimuli should manifest in terms of early (i.e., initial or fast) responses. Such an early response is functional for the detection and avoidance of immediate harm, which is why we measured such responses. If we were to examine slower, more deliberate, or delayed responses, it is possible that such responses to particular facets of nonthreatening-negativity might trump those to threatening stimuli. Again, our thesis pertains to early responses and that is where we see evidence for sensitivity to threat.

### Ontogeny Versus Phylogeny

Öhman offered an argument for threat sensitivity in terms of a neural "fear module" (Öhman et al., 2001; Öhman & Mineka, 2001, 2003). Such a module raises the possibility that sensitivity is conditioned uniquely or more strongly to the phylogenetic stimuli (e.g., snakes, spiders) on which it evolved than to ontogenetic threats of modern day (e.g., weapons; Blanchette, 2006; Brosch & Sharma, 2005; Fox et al., 2007). To explore this possibility, we recoded the threatening stimuli as being either ontogenetic (e.g., guns, weapons) or phylogenetic (e.g., animals, fire), and found the same functional effect for each. In Study 1, participants were faster to detect the ontogenetic ( $M = 1,979.46$  ms) than phylogenetic threat ( $M = 2,171.56$  ms),  $F(1, 92) = 47.20, p = .0001$ . Nonetheless, participants were faster to detect either threat type than the nonthreatening-negative image ( $M = 2,214.84$  ms),  $F_{\text{ontogenetic}}(1, 92) = 100.43, p = .0001$ , and  $F_{\text{phylogenetic}}(1, 92) = 5.23, p = .0246$ . In Study 2, initial attention was more likely drawn to both ontogenetic and phylogenetic threats than any other stimulus type. Specifically, (a) when paired with a nonthreatening-negative stimulus, participants first gazed at the ontogenetic threat on 63% of trials,  $t(4524) = 5.03, p = .0001$ , and the phylogenetic threat on 60% of trials,  $t(4524) = 3.68, p = .0002$ , and their odds did not differ,  $t(4524) = 0.83, p = .4166$ , OR = 1.13; (b) when paired with a neutral stimulus, participants first gazed at the ontogenetic threat on 65% of trials,  $t(4524) = 5.89, p = .0001$ , and the phylogenetic threat on 71% of trials,  $t(4524) = 7.36, p = .0001$ , and their odds did not differ,  $t(4524) = -1.57, p = .1161$ , OR = 0.78; and (c) when paired with a positive stimulus, participants first gazed at the ontogenetic threat on 61% of trials,  $t(4524) = 4.24, p = .0001$ , and the phylogenetic threat on 66% of trials,  $t(4524) = 5.97, p = .0001$ , and their odds did not differ,  $t(4524) = -1.64, p = .1016$ , OR = 0.78. Finally, in Study 3, startle-eyeblick amplitude did not differ between ontogenetic ( $M = 0.16$ ) versus phylogenetic ( $M = 0.08$ ) threats,  $F(1, 119) = 1.14, p = .2883$ , and they each produced stronger startle-eyeblick amplitudes than did the positive, neutral, or nonthreatening-negative images,  $F_s(1, 119) > 3.75, p_s < 0.055$ . These data support the idea of a flexible system that learns and incorporates an expanding repertoire of what constitutes threat.

### Implications of Threat Sensitivity for Evaluative Processing

Dual-process models of evaluation distinguish between automatic (implicit) and controlled (explicit) evaluative processes (Fazio & Olson, 2014; Gawronski & Bodenhausen, 2007). As we intimated in the introduction, such models do not delineate a speed or strength difference between positive and negative implicit evaluations. An implicit response to a positive stimulus is assumed equivalent to an implicit response to a

negative stimulus. The current data, however, suggest that such is not so and makes plausible a theoretical delineation between implicit evaluative threat processing and implicit evaluative valence processing. If evaluation is a dynamic process that unfolds over time (Cunningham, Zelazo, Packer, & Van Bavel, 2007), then threat evaluation may be temporally distinct and prior to valence processing. This implies a Dual Implicit Process (DIP) model in which an implicit threat process precedes (and potentially influences) a subsequent implicit valence process (positive vs. negative) which precedes (and potentially influences) explicit processes (March, Gaertner, & Olson, in press)

Such a dual implicit process perspective has interesting implications such that phobias, some addictions, and certain stereotypes (particularly those involving aggression or threat) can be disentangled from other evaluative responses. For example, implicit biases toward African Americans might be separable and functionally distinct in regard to threat versus positive-versus-negative evaluation. Indeed, implicit Black-danger stereotypes have unique power to draw attention to Black faces, whereas non-threat-related but negative Black-stereotypes do not (Donders, Correll, & Wittenbrink, 2008). This might also explain why White participants evidence stronger amygdala activation to subliminally presented Black than White faces (Cunningham et al., 2004). Furthermore, Black participants show an own-group shooter-bias against Blacks (Kahn & Davies, 2011), but also evidence ingroup favoritism on other implicit measures (e.g., evaluative priming, Fazio, Jackson, Dunton, & Williams, 1995; Implicit Association Test, Olson, Crawford, & Devlin, 2009). Such a pattern cannot be easily explained by current dual process models, but is easily handled by a DIP model that distinguishes implicit threat from implicit valence processing.

Clearly, the current data do not speak directly to a serial time course between implicit threat and implicit evaluative processing as proposed by the DIP model. The current data do, however, establish the preconditions necessary for such a DIP model (i.e., preferential early responding to threatening stimuli) and raise interesting possibilities for interpreting existing findings and making testable predictions.

## Conclusion

The current research indicates that the mind initially responds more strongly and quickly to threatening than nonthreatening-negative stimuli, and highlights the nuanced way disparate types of negatively valenced stimuli are evaluated. We suggest that integrating such sensitivity to threat into social-cognitive processes of evaluation would offer finer parsed models of evaluation that could account for a wider array of social functioning.

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## Supplemental Material

Supplementary material is available online with this article.

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Supplemental Table 1. *Mean (SD) Ratings, Luminance, and Red Value as a Function of Stimulus Set*

Stimulus Set <sup>a</sup>	Rating Type <sup>b</sup>			Luminance <sup>c</sup>	Red Value <sup>c</sup>
	Good	Bad	Threatening		
Positive	6.14 (0.76)	1.07 (0.18)	1.09 (0.11)	122.20 (29.95)	127.58 (30.11)
Neutral	4.14 (0.93)	1.15 (0.35)	1.16 (0.21)	121.15 (36.91)	124.74 (37.21)
NT-Negative	1.53 (0.47)	4.78 (1.14)	3.18 (1.31)	122.40 (21.74)	135.14 (27.36)
Threatening	2.02 (0.86)	4.40 (1.54)	5.73 (0.99)	121.52 (28.61)	130.59 (31.19)

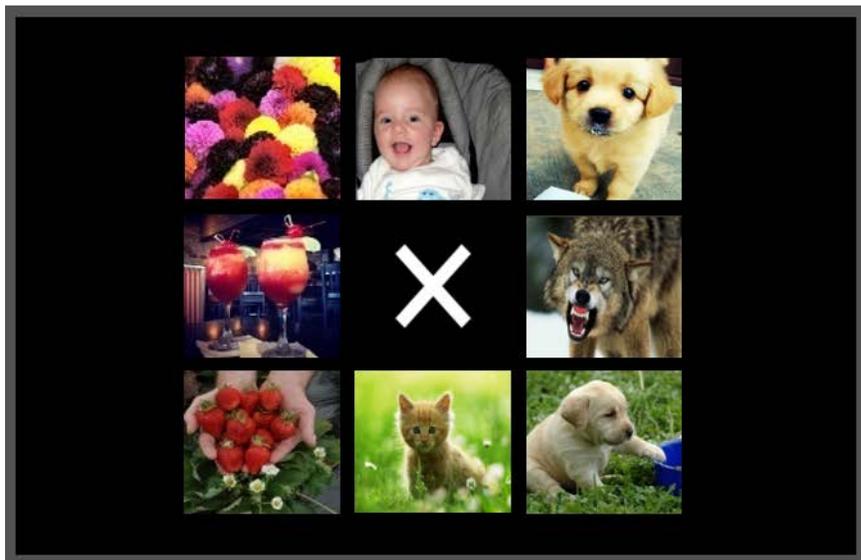
*Note.* NT-Negative = nonthreatening-negative

<sup>a</sup>Each set contains 40 images.

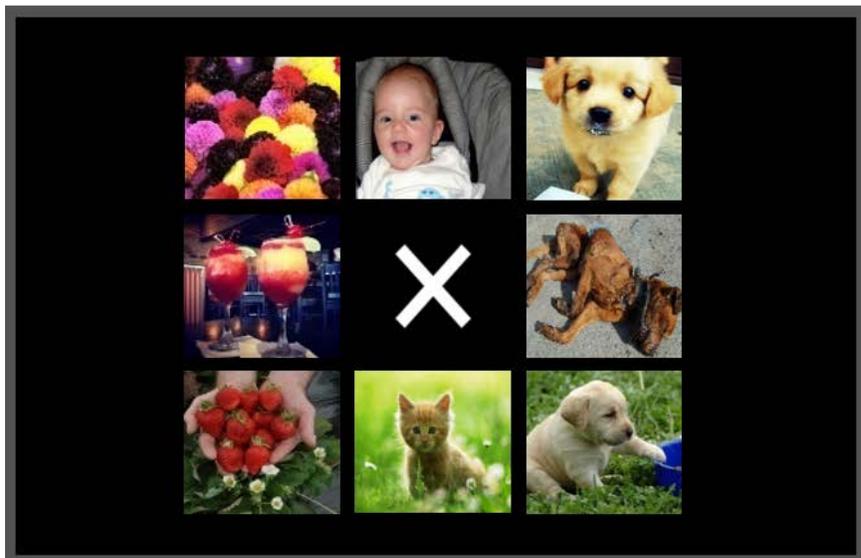
<sup>b</sup>Rating type varied between-subjects on 7-point scales (“1 = *Not at All*” to “7 = *Extremely*”).

<sup>c</sup>Obtained in Adobe Photoshop.

### A. Threatening



### B. Nonthreatening-negative



**Supplemental Figure 1.** Examples of 3 x 3 matrices used in Study 1. Panels A and B depict a threatening target and a nonthreatening-negative target, respectively, embedded among positive distractors.

## Supplemental Analysis

### Morbid Fascination

People experience morbid fascination toward certain negative stimuli (Oosterwijk et al., 2015; Rimé et al., 2005; Turner & Silvia, 2006) whereby they pay more attention to disgusting content (Rubenking and Lang, 2014). A morbid fascination account of our negative results suggests that startle responses to negative stimuli were attenuated relative to neutral because negative stimuli both failed to evoke avoidance behaviors and engendered information seeking behaviors (i.e. increased attentional interest). Absent a startle enhancing threat component, interest value toward negative stimuli diminished startle responses relative to neutral (Fillion, et al., 1998; Vanman et al., 2013). If such is the case, our eye-tracking data should reveal participants spend more time looking at negative paired with neutral stimuli. We analyzed gaze duration data with the expectation that morbid fascination would be more evident among persons low (but not high) in disgust sensitivity. That is, even though disgust sensitivity did not moderate the stimulus in each pair to which participants first gazed in Study 2, persons high in disgust sensitivity might intentionally avoid prolonged looking at negative stimuli and hence not evidence morbid fascination.

To test this possibility, we computed for each participant the mean time spent looking at each stimulus in the negative-neutral pairing and regressed time onto a factorial crossing of mean centered disgust and stimulus (negative vs. neutral), with the latter as a within-subject variable. Consistent with morbid fascination, there was a Stimulus x Disgust interaction,  $F(1, 61) = 10.16$ ,  $p = .0023$ , indicating that persons low in disgust sensitivity spent more time looking at the negative stimulus ( $M = 2020.18\text{ms}$ ,  $SE = 79.26$ ) than neutral stimulus ( $M = 1170.63\text{ms}$ ,  $SE = 82.80$ ),  $F(1, 61) = 34.00$ ,  $p = .0001$ , and persons high in disgust sensitivity looked equally at the

negative stimulus ( $M = 1527.99\text{ms}$ ,  $SE = 79.26$ ) and neutral stimulus ( $M = 1335.73\text{ms}$ ,  $SE = 82.80$ ),  $F(1, 61) = 1.74$ ,  $p = .1919$ . Explained otherwise, disgust sensitivity reduced time spent looking at the negative stimulus,  $b = -431.74\text{ms}$ ,  $t(61) = -4.39$ ,  $p = .0001$  and was unrelated to time spent looking at the neutral stimulus,  $b = 144.83$ ,  $t(61) = 1.41$ ,  $p = .1640$ . Repeating these analyses for the negative-positive pairing and the negative-threatening pairing revealed no Stimulus x Disgust interaction for the negative-positive pairing,  $F(1, 61) = 2.67$ ,  $p = .1072$ , nor the negative-threatening pairing,  $F(1, 61) = 0.05$ ,  $p = .8192$ , and no tendency to differentially look at the negative ( $M = 1581.50\text{ ms}$ ,  $SE = 62.40$ ) vs. positive stimulus ( $M = 1476.21\text{ ms}$ ,  $SE = 69.84$ ),  $F(1, 61) = 0.75$ ,  $p = .3900$ , nor the negative ( $M = 1454.45\text{ ms}$ ,  $SE = 55.58$ ) vs. threatening stimulus ( $M = 1565.69\text{ ms}$ ,  $SE = 51.14$ ),  $F(1, 61) = 1.46$ ,  $p = .2321$ .

Morbid fascination may be functional in that it compels attention toward ambiguously negative stimuli; the gory, disgusting, or dead object may signify that a threat is nearby, or it may simply be the remnant of a past but no longer salient threat. If ambiguity exists, examining the scene to gather information is necessary to plan future action. Morbid fascination is therefore one example of an atypical reaction to negative stimuli that challenges traditional conceptualizations assuming negativity prompts avoidance.