

Visual and behavioral responses to social and non-social threats: A multi-site replication[☆]

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ABSTRACT

Researchers have proposed that humans have evolved psychological mechanisms that facilitate the detection, rapid response, and subsequent avoidance of potential threats. However, some inconsistent results in the literature have called into question the robustness of these responses. Here, we sought to replicate previous findings on the rapid detection of both social (i.e., angry faces) and nonsocial (i.e., snakes) threats within a large and diverse sample of adults, and to examine the robustness of our effects across three data-collection sites using two response metrics—visual latency to detect threatening versus non-threatening stimuli and motor (i.e., button press) responses to indicate that threatening versus non-threatening targets had been detected. We found an advantage for both social (angry facial configurations) and non-social (snakes) threats across all three data collection sites, demonstrating that the phenomenon is both replicable and robust. Further, we found that the threat advantage was only significant for visual latency to first detect threatening stimuli and not for subsequent motor responses—the overall replication effect was driven by first fixations—suggesting that biases for threat might be perceptually based.

1. Introduction

Responding to threat quickly and efficiently is critical for survival. Because of the significant reproductive advantage associated with rapid identification of threatening stimuli, some researchers have proposed that humans have evolved psychological mechanisms that facilitate the detection and subsequent avoidance of potential threats (Öhman & Mineka, 2001). In support of this view, a large number of studies have shown that humans and nonhuman primates more rapidly detect threat-relevant than non-threat-relevant stimuli. This phenomenon has been documented across the lifespan, from infancy to adulthood (for comprehensive reviews, see Burris, Buss, et al., 2019; Burris, Oleas, et al., 2019; Cisler et al., 2009; Yiend, 2010).

Studies in this literature report similar results across different methods and different kinds of threats. Some studies, for example, have examined rapid detection of social threats, specifically threatening

emotional facial configurations, such as anger. These studies typically report that children and adults detect angry facial configurations more quickly than happy or neutral configurations. Further, these effects can be enhanced for adults with social anxiety (see Bar-Haim et al., 2007 for a review) or children with a behaviorally inhibited temperament (e.g., Burris, Buss, et al., 2019; Burris, Oleas, et al., 2019). In addition to social threats, there is an equally large literature investigating the rapid detection of nonsocial or non-human threats. Many of these studies focus on threatening animals like snakes and spiders, comparing detection of these animals to various non-threatening stimuli such as another animal or a plant. These studies typically report an advantage for snakes and spiders that is consistent in adults, children, infants, and even non-human primates (i.e., Shibasaki & Kawai, 2009).

Although many of the classic studies in this literature have focused on threats that have evolutionary significance, more recent research suggests that attention biases for threat are not specific to evolutionary

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threats, but are instead flexible, prioritizing any stimulus that has relevance to the perceiver. For example, modern threats like guns, syringes, and knives are detected more quickly than non-threatening objects (Blanchette, 2006; LoBue, 2010). Further, both adults and children detect a completely neutral stimulus more quickly than a perceptually similar control after being conditioned to associate that stimulus with an aversive shock or loud noise (children: Field, 2006; adults: Koster et al., 2004; Milders et al., 2006; Purkis & Lipp, 2009), suggesting that a bias for threat in visual detection can be learned.

Importantly, while the majority of visual search studies in this large and growing literature find an advantage for the detection of threatening over non-threatening stimuli, there are also studies that have failed to replicate this basic phenomenon (see Becker & Rheem, 2020). Further, a handful of these studies have failed to replicate an advantage for threat with samples collected internationally (e.g. Lazarević et al., 2020). In fact, like most research in psychological science more broadly, most of the research in this literature has been collected with White, middle-class adults, primarily sampled in Western, industrialized countries. It is possible that different areas of the world respond differently to different kinds of threat. For example, while snakes are not at all common in the US, they are in other countries in South America, Africa, and Australia. Further, there are environmental differences in the US that might make responses to threat variable (e.g., rural versus urban living; low-SES versus high-SES neighborhoods). Thus, it is important, at minimum, to ensure that our basic psychological phenomena replicate beyond our common convenience samples of White, middle-class adults. This is important, as it speaks to the universality of human responses to threat, which has been previously hypothesized to be adaptive, and therefore evolutionarily endowed (Öhman et al., 2001). However, it is possible that inconsistent results have been found because threat perception is actually environmentally specific and context dependent.

As a first step in expanding our examination of threat perception to different people living in different environments, here we sought to replicate and extend previous findings on the rapid detection of threatening stimuli in a large three-site study with diversity across both socioeconomic status and race/ethnicity. We examined the robustness of the phenomenon in three ways. First, we studied rapid detection of both social (i.e., angry faces) and nonsocial (i.e., snakes) threats using a single classic paradigm to see whether the effect replicates with two perceptually distinct kinds of threats. Previous studies generally focus on one kind of threat, so examining detection of two perceptually different types of threat within-subjects using the same paradigm is a novel contribution to the literature. Second, we examined whether the advantage for threat in both social and nonsocial stimuli replicates for three different data collection sites, with a large and diverse group of adults in the United States, which to our knowledge has not been done in previous work. Third, although we aimed to replicate findings using a classic paradigm where only a single behavioral response is typically measured, here we used two response metrics—visual latency to detect threatening versus non-threatening stimuli with an eye tracker, and motor (i.e., button press) responses to indicate that threatening versus non-threatening targets had been detected—to test whether the advantage for threat is perceptually based (e.g., latency to first fixation) or lies in motor responding (e.g., latency to button press from first fixation). This is also a novel contribution and can tell us about the mechanisms that guide rapid threat detection, and whether a bias in detection is driven by perception (measured here as latency to first fixate) or motor responses (latency to indicate by button press that a target was detected after it is first fixated). We understand that there are various paradigms that have been used to study threat detection, and we specifically chose to use a paradigm that is common of much of the most classic work in this field and would also allow us to examine two types of responses (perceptual and motor).

2. Materials and methods

2.1. Participants

Participants were recruited as part of the Longitudinal Anxiety and Temperament Study (LANTS), a longitudinal multi-site study of infants and their caregivers (Pérez-Edgar et al., 2021). The data were collected between 5/16/2017 and 3/11/2020, and the data were accessed for analysis in January of 2021. Participants were recruited across three different data collection sites: State College, PA ($N = 168$), Harrisburg, PA ($N = 82$), and Newark, NJ ($N = 109$) and were enrolled when their infants were 4 ($N = 298$), 8 ($N = 46$), or 12 ($N = 13$) months of age. For the purposes of our analyses, we only used data from the first time point in which the participant provided data on the task. Of the 357 enrolled families, 298 caregivers attempted the task at least once. Most of these caregivers were female ($N = 295$). Given that we had so few males ($N = 3$), and that researchers have not reported gender differences in rapid threat detection for snakes and angry faces previously, we excluded men from the analysis to reduce potential noise.

The final sample included 246 women who completed the eye-tracking task during one of their infant's assessments in the lab. They were on average 31.02 years old ($SD = 4.87$, Range = 16.69–41.59, $N = 189$, 59 declined to respond) at the time they first completed the eye tracking task. Additionally, 130 (52.85 %) participants self-identified as Non-Latinx White, 46 (18.70 %) as Latinx, 34 (13.82 %) as Black/African American, 9 (3.66 %) as Asian/Pacific Islander, 12 (4.88 %) as more than one race, and 15 (6.10 %) declined to provide this information. In terms of household income, a plurality ($n = 104$, 42.28 %) of participants identified as making a combined annual household income of above \$60,000, with an additional 19 (7.72 %) making between \$51,000–\$60,000, 12 (4.88 %) making between \$41,000–\$50,000, 14 (5.69 %) making between \$31,000–\$40,000, 18 (7.32 %) making between \$21,000–\$30,000, 12 (4.88 %) making between \$16,000–\$20,000, and 29 (11.79 %) making \$15,000 or less. An additional 38 (15.45 %) participants declined to provide this information. A plurality of participants ($N = 48,19.51$ %) identified their highest level of education as holding a graduate training degree, with an additional 41 (16.67 %) having some graduate training, 53 (21.54 %) holding a college degree, 44 (17.89 %) having trade, technical, or some college experience, 27 (10.98 %) having a high school degree, 10 (4.07 %) having some high school, 2 (0.81 %) having a grade school level education, and an additional 21 (8.54 %) who declined to provide this information. The demographic breakdown for each individual site is listed in Table 1.

Participants completed the visual search task in the lab. Most participants completed online questionnaires at home prior to the visit, but in some cases, they were completed in the lab or over the phone. The Institutional Review Board at Rutgers University approved all procedures on 7/27/2016, and parents provided written consent and were compensated for their participation. Authors had access to information that could identify individual participants during and after data collection.

2.2. Visual search task

An adaptation of the classic adult visual search task, designed to assess rapid attention to threat (Öhman et al., 2001), was presented to the participants, relying on both gaze and button presses to assess attentional responses to the stimuli. Eye tracking data were collected across sites using SMI eye tracking systems, either the SMI RED or REDm system, both offering comparable specifications and capabilities (SensoMotoric Instruments, Teltow, Germany). These eye trackers are desktop mounted and no chin rests were used. The temporal resolution of the systems is 60 Hz. Calibration was 5 points with a 5-point validation as per SMI recommendations. Calibration was repeated until acceptable values (<1degree) were reached.

Table 1
Demographics by Site.

Race/ethnicity	State college, PA	Harrisburg, PA	Newark, NJ
White (Non-Latinx)	89(36.2 %)	35(14.2 %)	6(2.4 %)
Latinx	7(2.8 %)	9(3.7 %)	30(12.2 %)
Black/African American	0(0.0 %)	12(4.9 %)	22(8.9 %)
Asian/Pacific Islander	7(2.8 %)	0(0.0 %)	2(0.8 %)
More than One Race	7(2.8 %)	3(1.2 %)	2(0.8 %)
No response	6(2.4 %)	1(0.4 %)	8(3.3 %)

Income	State college, PA	Harrisburg, PA	Newark, NJ
(1) 15 k or less	3(1.2 %)	8(3.3 %)	18(7.3 %)
(2) 16 k–20 k	1(0.4 %)	3(1.2 %)	8(3.3 %)
(3) 21 k–30 k	4(1.6 %)	5(2.0 %)	9(3.7 %)
(4) 31 k–40 k	7(2.8 %)	5(2.0 %)	2(0.8 %)
(5) 41 k–50 k	7(2.8 %)	3(1.2 %)	2(0.8 %)
(6) 51 k–60 k	12(4.9 %)	5(2.0 %)	2(0.8 %)
(7) above 60 k	71(28.9 %)	26(10.6 %)	7(2.8 %)
No response	11(4.5 %)	5(2.0 %)	22(8.9 %)

Education	State college, PA	Harrisburg, PA	Newark, NJ
(1) Grade school	0(0.0 %)	0(0.0 %)	2(0.8 %)
(2) Some high school	1(0.4 %)	3(1.2 %)	6(2.4 %)
(3) High school graduate	5(2.0 %)	9(3.7 %)	13(5.3 %)
(4) Trade, technical or some college	11(4.5 %)	16(6.5 %)	17(6.9 %)
(5) College graduate	31(12.6 %)	14(5.7 %)	8(3.3 %)
(6) Graduate training	26(10.6 %)	11(4.5 %)	4(1.6 %)
(7) Graduate degree (M.D., J.D., D.D.S., Ph.D.)	38(15.4 %)	4(1.6 %)	6(2.4 %)
No response	4(1.6 %)	3(1.2 %)	14(5.7 %)

Adults completed two blocks of the task in a random order. The face block consisted of 72 trials in which a 3 × 3 matrix of emotional faces was presented to the participant. There were 4 trial conditions: angry target-present (24 trials), angry target-absent (12 trials), happy target-present (24 trials), and happy target-absent (12 trials). In the angry target-present trials there were eight happy faces and one angry target face. In the angry target-absent trials there were 9 happy faces, and vice versa for the happy target trials. Twenty-four photographs from the NimStim stimulus set (approximately equal numbers of male and female faces; Tottenham et al., 2009) were used, each appearing once as the target in an angry target-present trial and once as the target in a happy target-present trial. Within the 3 × 3 matrix, each face had a width of 15 % of the screen and a height of 33 % of the screen, with images directly adjacent to one another and white bars present on the left and right side of the matrix (Fig. 1). Trial order, target position, and distractor identities and positions were all randomized. Participants were instructed to press the “F” key if all stimuli were from the same category or the “J” key if one of the images were from a different category. Participants then pressed the space key to advance each trial after responding. Note that the target-absent trials were only used to give the participants a task to maintain their attention throughout the experiment and were not analyzed.

The animals block consisted of 72 trials, each with a 3 × 3 matrix of pictures of snakes and frogs presented to the participant. There were 4 trial conditions: snake target-present (24 trials), snake target-absent (12 trials), frog target-present (24 trials), and frog target-absent (12 trials). In the snake target-present trials there were eight frogs and one snake target. In the snake target-absent trials there were 9 frogs, and vice versa for the frog target trials. Twenty-four images of animals were used, each appearing once as the target in a snake present trial and once as the target in a frog present trial. Within the 3 × 3 matrix, each animal image had a width of 25 % of the screen and a height of 33 % of the screen, with images directly adjacent to one another and white bars present on the

left and right side of the matrix. Trial order, target position, and distractor images and positions in the matrix were all randomized. Participants were instructed to press the “F” key if all stimuli were from the same category or the “J” key if one of the images were from a different category. Participants then pressed the space key to advance each trial after responding.

Areas of interest (AOIs) were drawn as squares enclosing each separate image in the matrix. All analyses were based on gaze to these designated AOIs. Latency to visually fixate the target on target-present trials, as well as accuracy and reaction time of button press responses were extracted with BeGaze software (SensoMotoric Instruments, Teltow, Germany). Based on the close proximity of the AOIs within the matrices, we excluded any data from participants who calibrated to >1 degree of visual angle.

2.3. Data preparation

For the button press data, we excluded any trial in which the participant did not select a response button (e.g., pressed the space bar to advance the trial before choosing an “F” or “J” response) or selected a button that was not one of the possible responses. Additionally, we excluded any button press data from participants who were <70 % accurate ($N = 4$ for animal/frog, $N = 8$ for animal/snake with 4 overlapping with frog, $N = 24$ for face/angry, $N = 29$ for face/happy with 14 overlapping with happy). This criterion was based on calculating the average proportion of accurate trials participants provided for each condition (frog targets, $M = 0.92$, $SD = 0.11$; snake targets, $M = 0.89$, $SD = 0.13$; angry targets, $M = 0.84$, $SD = 0.14$; happy targets, $M = 0.83$, $SD = 0.14$), and eliminating participants who provided fewer accurate trials that were 2 SD's from the largest mean (i.e., frog targets). Finally, we excluded any extreme values across response types (first fixations and button presses) that were greater than or less than three standard deviations from the mean in each task and condition (Face/Angry $N = 2$, Face/Happy $N = 1$, Animal/Frog $N = 3$, Animal/Snake $N = 4$ with 2 overlapping with frog). The means reported here were based on all available data for each condition and variable, after the exclusions were made.

3. Results

3.1. Replication of the threat effect

Here the primary goal was to examine whether the results of our visual search tasks replicated previous work on the rapid detection of threatening stimuli in adults. To do this, we performed a repeated measures ANOVA with stimulus category (faces; animals) and threat condition (threatening: angry face target, snake animal target; nonthreatening: happy face target; frog animal target) as within subjects factors, and button press response latency as the outcome measure (see Table 2 for descriptives, and Fig. 2). As predicted, there was a significant main effect of social (faces versus animals) category, $F(1,230) = 780.81$, $p < .001$, $\eta_p^2 = 0.77$, 95 % CI [0.72, .81] a significant main effect of threat (threat vs. non-threat) condition, $F(1, 230) = 105.96$, $p < .001$, $\eta_p^2 = 0.32$, 95 % CI [0.22, .40] and a significant category by threat interaction, $F(1, 230) = 54.05$, $p < .001$, $\eta_p^2 = 0.19$, 95 % CI [0.11, .28]. In line with previous findings, participants were significantly faster to indicate the presence of a discrepant threatening target (Social: $M = 2886.55$ ms $SD = 1019.96$, Nonsocial: $M = 1740.07$ ms, $SD = 530.51$) than non-threatening target (Social: $M = 3257.71$ ms, $SD = 995.30$, Nonsocial: $M = 1823.09$ ms, $SD = 555.19$). Follow-up t -tests demonstrated that this was the case for both the face condition, $t(240) = 10.74$, $p < .001$, 95 % CI [439.23, 303.11], $d = 0.37$, and the animal condition, $t(233) = 3.90$, $p < .001$, 95 % CI [41.06, 124.99], $d = 0.15$. Further, responses to targets in the animal condition ($M_{seconds} = 1781.58$, $SD = 517.98$) were faster overall than in the face condition ($M = 3072.13$ s, $SD = 971.36$), $t(230) = 27.94$, $p < .001$, 95 % CI [1164.36, 1341.03], $d = 1.66$,



Fig. 1. Sample matrix schematic with an angry target present.

Table 2
Button-press latency means by site.

Site	N for social	Social threat, M (SD)	Social non-threat, M (SD)	N for nonsocial	Non-social threat, M (SD)	Non-social non-threat, M (SD)
State college, PA	112	2665.68 (654.15)	3055.85 (658.72)	113	1609.60 (368.68)	1652.43 (324.83)
Harrisburg, PA	60	2839.66 (1081.28)	3244.97 (1017.57)	55	1723.83 (704.64)	1839.35 (650.85)
Newark, NJ	69	3285.83 (1309.46)	3596.47 (1306.10)	66	1976.96 (524.75)	2101.75 (664.43)
Overall sample	241	2886.55 (1019.96)	3257.71 (995.30)	234	1740.07 (530.51)	1823.09 (555.19)

potentially due to the added visual complexity of face stimuli. The effect of threat was larger for the social condition, which is reflected in the significant interaction. This is likely because the snake/frog stimuli were simpler, and less similar to each other than the face stimuli, making responses to the animals faster overall and closer to ceiling than the responses for faces.

3.2. Robustness of the threat effect

To investigate the robustness of our effects, we examined whether the advantage for both social and non-social threats was present across all three data collection sites. Our goal here was to examine whether the advantage for threat was present with similar effect sizes across sites.

Thus, we analyzed each site separately instead of including site as a variable in an omnibus ANOVA, which would preclude us from comparing effect sizes across sites. Accordingly, we ran a series of three ANOVAs (one for each site) with stimulus category (faces; animals) and threat condition (threatening: angry face target, snake animal target; nonthreatening: happy face target; frog animal target) as within subjects factors, and with button press response latency as the outcome measure (Fig. 3).

We found the same significant effects and similar effect sizes across sites, suggesting that the advantage for threat is a robust and replicable phenomenon (see Table 2 for descriptives by site, Table 3 for ANOVA results). More specifically, across sites, we found main effects of social category and threat condition, and a category by threat interaction.

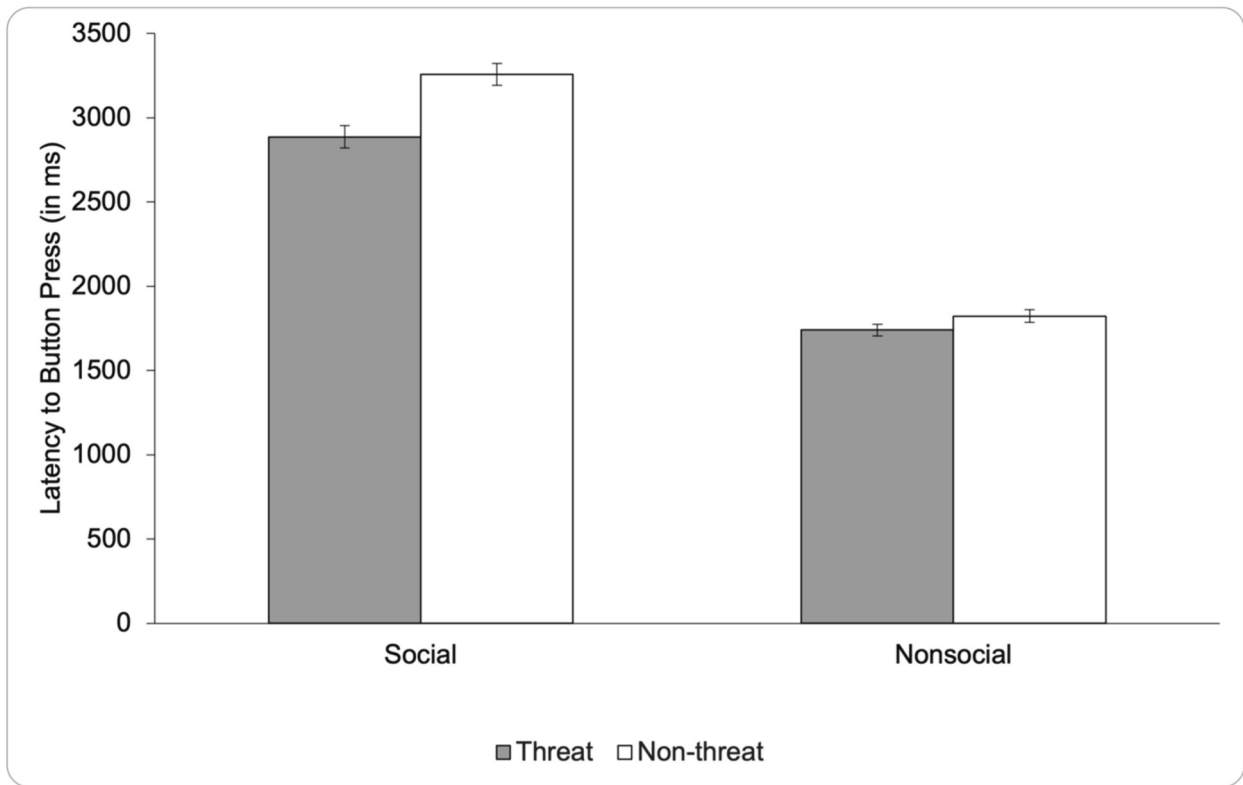


Fig. 2. Means for button-press responses by condition. Participants more quickly detected both social (first set of bars) and nonsocial threats (second set of bars) faster than non-threats, and they detected nonsocial threats (snakes) more quickly than social threats (angry faces) overall (third set of bars). Error bars represent standard errors.

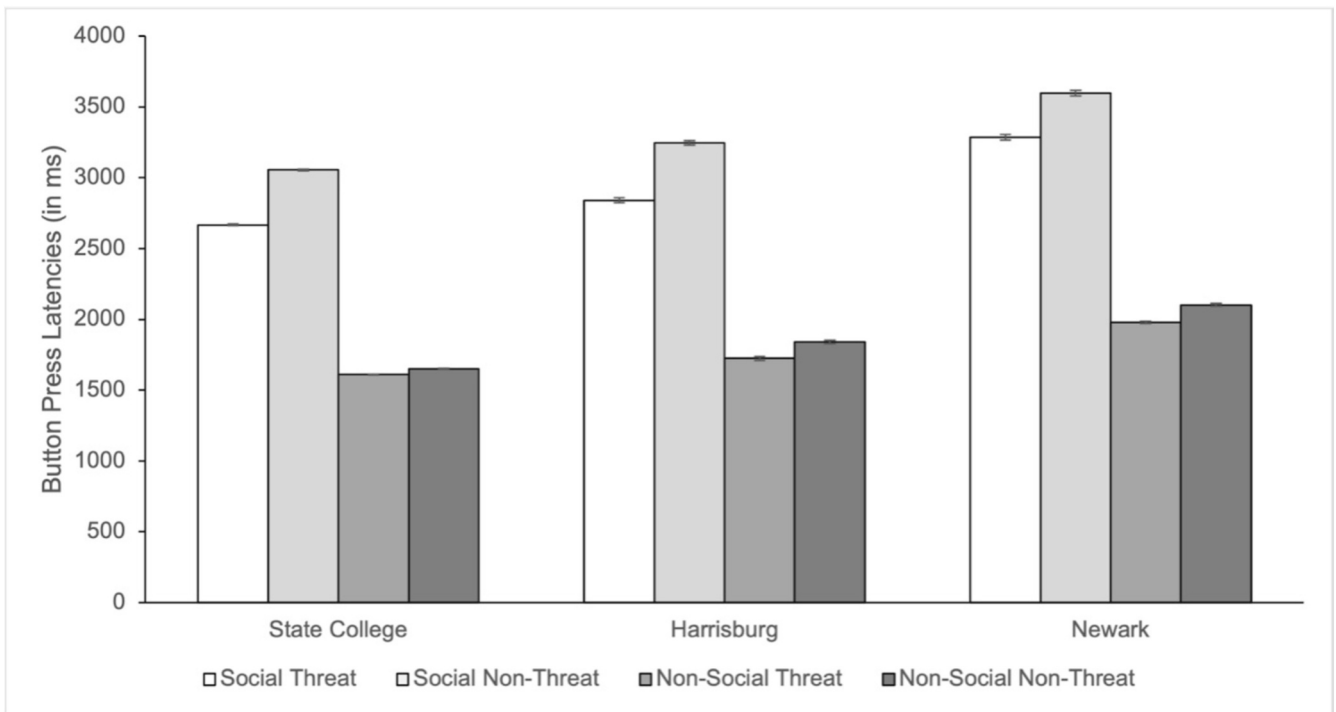


Fig. 3. Means for button-press responses by condition by site.

Follow-up *t*-tests showed that participants were faster to detect angry face targets than happy face targets, faster to detect snake targets than frog targets, and faster to detect nonsocial stimuli than social stimuli

overall. The only exception was that the advantage for snakes at the State College site was marginal, $t(112) = 1.89, p = .06$, but again, the effect sizes for the main effect of threat across the three sites were

Table 3
Results of ANOVAs for button press latency and post-hoc comparisons by site.

	Main effects		Interaction
	Social vs. nonsocial	Threat vs. non-threat	Social category * threat condition
State College, PA	$F(1, 109) = 697.24, p < .001, \eta_p^2 = 0.87$	$F(1, 109) = 63.83, p < .001, \eta_p^2 = 0.37$	$F(1, 109) = 49.73, p < .001, \eta_p^2 = 0.31$
Harrisburg, PA	$F(1, 54) = 199.41, p < .001, \eta_p^2 = 0.79$	$F(1, 54) = 27.41, p < .001, \eta_p^2 = 0.34$	$F(1, 54) = 14.20, p < .001, \eta_p^2 = 0.21$
Newark, NJ	$F(1, 65) = 128.91, p < .001, \eta_p^2 = 0.67$	$F(1, 65) = 21.08, p < .001, \eta_p^2 = 0.25$	$F(1, 65) = 4.34, p = .04, \eta_p^2 = 0.06$
Overall	$F(1, 230) = 780.81, p < .001, \eta_p^2 = 0.77$	$F(1, 230) = 105.96, p < .001, \eta_p^2 = 0.32$	$F(1, 230) = 54.05, p < .001, \eta_p^2 = 0.19$

	Post-Hoc comparisons		
	Social vs non-social stimuli	Social threat	Non-social threat
State College, PA	$t(109) = 26.41, p < .001, 95\% \text{ CI } [1128.98, 1312.22]$	$t(111) = -8.63, p < .001, 95\% \text{ CI } [-479.73, -300.60]$	$t(112) = 1.89, p = .06, 95\% \text{ CI } [-2.19, 87.84]$
Harrisburg, PA	$t(54) = 14.12, p < .001, 95\% \text{ CI } [1060.84, 1411.91]$	$t(59) = -5.63, p < .001, 95\% \text{ CI } [-549.33, -261.29]$	$t(54) = 2.34, p = .02, 95\% \text{ CI } [16.56, 214.47]$
Newark, NJ	$t(65) = 11.35, p < .001, 95\% \text{ CI } [1087.64, 1551.93]$	$t(68) = -4.26, p < .001, 95\% \text{ CI } [-456.13, -165.16]$	$t(65) = 2.51, p = .02, 95\% \text{ CI } [25.49, 224.09]$
Overall	$t(230) = 27.94, p < .001, 95\% \text{ CI } [1164.36, 1341.03]$	$t(240) = 10.74, p < .001, 95\% \text{ CI } [-439.23, -303.11]$	$t(233) = 3.90, p < .001, 95\% \text{ CI } [41.06, 124.99]$

similar.

3.3. The role of different response metrics

Finally, to investigate the role of different response metrics in driving rapid threat detection, we ran two repeated measures ANOVAs with stimulus category (faces; animals) and threat condition (threatening: angry face target, snake animal target; nonthreatening: happy face target; frog animal target) as within subjects factors. The first outcome measure was latency to first fixate the target stimuli, which measures the potential perceptual factors that drive rapid threat detection. The second outcome measure was latency to indicate that a discrepant image was present via button press after it was first fixated, measuring how motor responses might drive rapid threat detection. To examine this variable, we calculated difference scores between the time it took for the participants to visually fixate the target and the latency to push the button indicating that the target had been detected.

In terms of latency to first fixate discrepant target images, we found a significant main effect of social category, $F(1, 170) = 997.75, p < .001, \eta_p^2 = 0.85, 95\% \text{ CI } [0.82, 0.88]$ a significant main effect of threat condition, $F(1, 170) = 347.11, p < .001, \eta_p^2 = 0.67, 95\% \text{ CI } [0.59, .73]$, and a significant category by threat interaction, $F(1, 170) = 106.91, p < .001, \eta_p^2 = 0.39, 95\% \text{ CI } [0.28, .48]$. Again, threatening stimuli (Social: $M = 1213.12 \text{ ms}, SD = 289.50$; Nonsocial: $M = 756.94 \text{ ms}, SD = 154.37$) were visually fixated significantly faster than non-threatening stimuli

Table 4
First fixation latency means by site.

Site	N for social	Social threat, M (SD)	Social non-threat, M (SD)	N for nonsocial	Non-social threat, M (SD)	Non-social non-threat, M (SD)
State college, PA	104	1194.49 (244.56)	1610.16 (362.32)	96	733.06 (134.79)	820.89 (137.39)
Harrisburg, PA	46	1184.64 (316.85)	1540.83 (383.84)	42	750.43 (164.74)	819.38 (160.24)
Newark, NJ	57	1270.12 (336.15)	1530.66 (365.76)	52	806.28 (170.48)	945.18 (205.52)
Overall Sample	171	1213.12 (289.50)	1572.86 (368.26)	190	756.94 (154.37)	854.57 (171.95)

(Social: $M = 1572.86 \text{ ms}, SD = 368.26$; Nonsocial: $M = 854.57 \text{ ms}, SD = 171.95$) for both the face condition, $t(206) = 17.12, p < .001, 95\% \text{ CI } [401.17, 318.30], d = 1.09$, and the animal condition, $t(189) = 8.35, p < .001, 95\% \text{ CI } [74.56, 120.71], d = 0.60$. Again, the effects were larger for the social than non-social condition, and fixations were faster overall for the animal condition than for the face condition, $t(170) = 31.59, p < .001, 95\% \text{ CI } [553.18, 626.93]$. These results were the same when broken down across the three sites (see Table 4 for descriptives, Table 5 for ANOVAs).

In terms of button-press responses, results of the ANOVA on difference scores between the time it took for the participants to visually fixate the targets and the latency to push the button indicating that the target had been detected only showed a significant main effect of social condition; using a difference score, button presses for animals ($M = 946.62 \text{ ms}, SD = 387.75$) were faster than for faces ($M = 1578.66 \text{ ms}, SD = 627.26$), $F(1, 167) = 253.40, p < .001, \eta_p^2 = 0.60, 95\% \text{ CI } [0.51, .67]$, but there was no main effect of threat condition ($F(1, 167) = 0.11, p > .05, \eta_p^2 < 0.001$) and no interaction ($F(1, 167) = 0.001, p > .05, \eta_p^2 < 0.001$). These results suggest that the advantage for threat in visual search tasks likely lies with the ability to first fixate or detect the presence of threat, and not necessarily the ability to make a motor response particularly quickly once a threatening stimulus has been fixated.

It is possible that once participants visually fixated a target, they then searched several distractor stimuli and returned to the target to ensure

Table 5
Results of ANOVAs for first fixation latencies and post-hoc comparisons by site.

	Main effects		Interaction
	Social vs. non-social	Threat vs. non-threat	Social category * threat condition
State college, PA	$F(1, 89) = 604.62, p < .001, \eta_p^2 = 0.87$	$F(1, 89) = 270.27, p < .001, \eta_p^2 = 0.75$	$F(1, 89) = 130.58, p < .001, \eta_p^2 = 0.60$
Harrisburg, PA	$F(1, 34) = 250.81, p < .001, \eta_p^2 = 0.88$	$F(1, 34) = 60.76, p < .001, \eta_p^2 = 0.64$	$F(1, 34) = 26.14, p < .001, \eta_p^2 = 0.44$
Newark, NJ	$F(1, 45) = 196.89, p < .001, \eta_p^2 = 0.81$	$F(1, 45) = 53.15, p < .001, \eta_p^2 = 0.54$	$F(1, 45) = 3.59, p = .06, \eta_p^2 = 0.07$
Overall	$F(1, 170) = 997.75, p < .001, \eta_p^2 = 0.85$	$F(1, 170) = 347.11, p < .001, \eta_p^2 = 0.67$	$F(1, 170) = 106.91, p < .001, \eta_p^2 = 0.39$

	Post-hoc comparisons		
	Social vs non-social stimuli	Social threat	Non-social threat
State college, PA	$t(89) = 24.59, p < .001, 95\% \text{ CI } [582.70, 685.16]$	$t(103) = -16.76, p < .001, 95\% \text{ CI } [-464.86, -366.49]$	$t(95) = 5.72, p < .001, 95\% \text{ CI } [57.34, 118.32]$
Harrisburg, PA	$t(34) = 15.84, p < .001, 95\% \text{ CI } [509.65, 659.70]$	$t(45) = -6.96, p < .001, 95\% \text{ CI } [-459.24, -253.14]$	$t(41) = 2.86, p < .01, 95\% \text{ CI } [20.31, 117.59]$
Newark, NJ	$t(45) = 14.03, p < .001, 95\% \text{ CI } [435.34, 581.27]$	$t(56) = -6.04, p < .001, 95\% \text{ CI } [-346.97, -174.11]$	$t(51) = 5.60, p < .001, 95\% \text{ CI } [89.08, 188.72]$
Overall	$t(170) = 31.59, p < .001, 95\% \text{ CI } [553.18, 626.93]$	$t(206) = 17.12, p < .001, 95\% \text{ CI } [401.17, 318.30]$	$t(189) = 8.35, p < .001, 95\% \text{ CI } [74.56, 120.71]$

that a discrepant image was indeed detected. This process may have slowed motor responses for targets fixated particularly quickly, impacting responding to threatening stimuli (which were detected faster) more than non-threatening stimuli. To explore this possibility, we examined the average number of revisits to the target stimulus for each condition. A revisit was defined as any fixation to the target AOI after the initial fixation, so a revisit of 1 would indicate that the participant visually detected the target, looked away, and then returned once before making a behavioral response to advance the trial. In congruence with the other eye tracking and button press data, the means for revisits are slightly higher for the social condition than the nonsocial condition, but overall, participants fixated the target less than two total times during a trial and did not spend a significant amount of time revisiting the target image once it has been initially fixated. These results suggest that participants on average did not revisit the target images multiple times, and revisits did not differentially impact behavioral responding for threatening and non-threatening stimuli (see Table 6).

4. General discussion

The current study aimed to replicate the rapid detection of two different types of threats in a single classic paradigm across a three-site sample that varied in both socioeconomic status and race/ethnicity. We replicated the basic phenomenon, showing that participants detect both social (angry facial configurations) and non-social (snakes) categories of threat more quickly than non-threats, demonstrating that the phenomenon is both replicable and robust. In terms of response metrics, we found that participants were faster to visually fixate both non-social and social categories of threat when compared to non-threat. This was not the case for the first fixation to button press: While participants showed a bias to visually detect threatening stimuli, participants were equally fast to make a motor response to indicate that a target was present, regardless of threat relevance. Thus, the replicated effect was driven by first fixations, suggesting that rapid threat detection may be driven by attentional processes, rather than motor responses. However, although motor responding did not add to the perceptual advantage for threat, the advantage in perception was enough to replicate the overall effect in button-press responses, suggesting that an advantage in perception does facilitate an advantage for threat in behavioral responding.

The suggestion that rapid detection of threat might be driven by perceptual processes is neither new nor surprising given the inconsistencies reported in previous literature. In fact, several researchers have concluded that low-level stimulus characteristics may play a major role in the rapid detection of various stimuli regardless of threatening nature or emotional valence (Becker & Rheem, 2020; Savage et al., 2016, 2013). We do not disagree. However, we argue it is possible that multiple interacting factors could drive the rapid detection of various stimuli, including both low-level stimulus characteristics and threatening valence (e.g., Gerritsen et al., 2008; LoBue, 2016). In fact, one study found that low-level perceptual features, negative information about the stimulus, and the participants' emotional state all led to a bias in detecting otherwise neutral stimuli, and that when examined together, all three of these factors potentially play an additive role in rapid detection of threat (LoBue, 2014). Thus, when using a standard button-press task with a large normative sample of adults, it is not necessarily surprising that rapid detection was most robustly guided by perceptual processes.

Altogether, this research can provide one model for how we can address inconsistencies in visual search research, and psychological research more broadly. First, large-scale replications can help us confirm

the robustness of results reported in previous literature. Second, we sampled from different locations, making sure that our samples are more inclusive and representative of the general population we are attempting to describe. Indeed, because of this sampling technique, our overall sample achieved representation in Black and Latinx participants—who are typically grossly underrepresented in psychological studies—that is nearly identical to national means for the United States (Latinx, 19 % in our sample and nationally; Black, 14 % in our sample and nationally, according to statistics from the U.S. Census Bureau). However, it is also important to note that our data were collected only within the United States. As mentioned previously, other studies have attempted to replicate similar findings with adults and with children internationally (e.g. Lazarević et al., 2020). This work is important, as it speaks to the universality of human responses to threat, which has been previously hypothesized to be adaptive, and therefore evolutionarily endowed (Öhman et al., 2001). That being said, future studies that include international replications are extremely important for discovering whether our propensity to detect snake and face threats is universal, especially in countries where views of snakes and where emotional representations of threat might differ from those in the United States.

While this study contributes to our understanding of rapid threat detection, there are several limitations which should be noted. Given the complexity of the design and the multiple layers of conditions and stimulus types, we took a conservative approach to data filtering and thus lost participants who only completed one condition. However, while this conservative approach negatively impacted our overall sample size, we still maintained a robust sample in line with or far surpassing the sample sizes seen in other studies within the threat detection literature. Further, the current sample only included women from an existing longitudinal study. This sample was also a community sample of adults beyond college age, unlike what is typically seen in most visual detection studies. Although researchers have not reported any gender differences in rapid threat detection for snakes and angry faces previously, future studies should aim to replicate these findings with men, as men have been reported to be more sensitive than women to the detection of some categories of threat, like weapons (see Sulikowski, 2022; Sulikowski & Burke, 2014). Finally, to replicate designs used commonly in classic work (e.g., Öhman et al., 2001), we compared trials in which participants detected angry targets to happy distractors and vice versa in the social conditions. Although this design allowed us to replicate previous work using one paradigm, it did not allow us to examine detection of threatening targets without the need for attention to compete with other emotionally salient stimuli. We see this as an advantage—as in the real world, there are likely competing stimuli in visual attention both with and without emotional salience—but future research replicating other commonly used visual search designs is important for determining the mechanisms that guide rapid detection of threat.

Taken together, the current study replicates and extends previous research demonstrating that adults detect threatening stimuli faster than non-threatening stimuli. The findings from the current study build on this work and provide evidence to suggest that the advantage for threat is present for both social and nonsocial stimuli, when measured via eye tracking visual latency and button press latency. Further, we found this to be the case across three data collection sites, and thus this work provides evidence for the robustness of the effect. Finally, we find that the threat advantage seems to be restricted to time to first fixation, and the effect does not necessarily manifest in post-fixation processes preceding a button-press response.

CRedit authorship contribution statement

Jessica L. Burris: Writing – original draft, Project administration, Investigation, Formal analysis, Data curation, Conceptualization. **Lori B. Reider:** Writing – review & editing, Methodology, Investigation, Formal analysis. **Denise S. Oleas:** Writing – review & editing,

Table 6

Number of revisits to target AOIs by emotion category.

	Frog target	Snake target	Happy target	Angry target
Mean (SD)	0.35 (0.24)	0.48 (0.45)	0.78 (0.33)	0.73 (0.24)

Investigation. **Kristin A. Buss:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Koraly Pérez-Edgar:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Conceptualization. **Vanessa LoBue:** Writing – original draft, Supervision, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization.

Declaration of competing interest

The authors of the current manuscript have no conflicts of interest to report.

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Data availability

Data will be made available on request.

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