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The Shape of Threat: Simple Geometric Forms Evoke Rapid and Sustained Capture of Attention

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Previous work has indicated that simple geometric shapes underlying facial expressions are capable of conveying emotional meaning. Specifically, a series of studies found that a simple shape, a downward-pointing "V," which is similar to the geometric configuration of the face in angry expressions, is perceived as threatening. A parallel line of research has determined that threatening stimuli more readily capture attention. In five experiments, the authors sought to determine whether this preferential processing was also present for the simple geometric form of a downward-pointing "V." Using a visual search paradigm, across these experiments the authors found that, when embedded in a field of other shapes, downward-pointing V's were detected faster and, in some cases, more accurately than identical shapes pointing upward. These findings indicate that the meaning of threat can be conveyed rapidly with minimal stimulus detail. In addition, in some cases, during trials of homogeneous fields of stimuli, fields of downward-pointing V's led to slower response times, suggesting that this shape's ability to capture attention may also extend to difficulty in disengaging attention as well.

Keywords: emotion perception, visual search, attentional bias, speeded detection, threat

Major programs of research (cf. Ekman, 1973, 2003) provide substantial evidence to support Darwin's (1872/1998) proposal that facial displays of emotion are expressed in similar ways in all cultures. This universality suggests that the sign vehicles that Ekman (1982) identified in the facial display of an emotion are served by a parallel set of innate feature detectors that facilitate the rapid recognition of the facial expression. This hypothesized set of feature detectors Ekman (2003) termed the "autoappraiser," a term that directs our attention to those sets of innate appraisal mechanisms that permit observers to decode an emotional display. To further clarify our understanding of the stimuli that such "appraisers" might be designed to identify, a set of studies (cf. Aronoff, 2006; Aronoff, Barclay, & Stevenson, 1988; Aronoff, Woike, & Hyman, 1992) examined the sign vehicles that attract attention to a display of anger, reasoning that it would be an evolutionary benefit for the observer to recognize quickly such threats from another (Hansen & Hansen, 1994; Lundqvist & Öhman, 2005). A set of naturalistic and experimental studies (Aronoff et al., 1988; Aronoff et al., 1992) sought to identify the elementary features in facial expressions that convey threat or happiness (as a contrasting visual image) as measured by their effects on a set of subjective semantic differential scales (Osgood, Suci, & Tannenbaum, 1957) that indicate the degree of "badness," "potency," and "activity" of each visual stimulus examined. These studies found that angular V-shaped images (similar to the angles in the eyebrows, cheeks, chin, and jaw in angry expressions) and rounded images (similar to the curves found in the cheeks, eyes, and mouth in happy expressions) conveyed an angry and a happy meaning, respectively (Aronoff, 2006; Aronoff et al., 1988, 1992). In fact, these studies provide evidence that simple nonrepresentational lines presented in different orientations and combinations, as well as large-scale static and dynamic configural shapes made by the whole body, provide the same information as do displays of specific facial features.

These results, which focused on the configural stimuli formed by the movement of the face as a whole rather than the shape of single sign vehicles, are supported by Bassili's (1978, 1979) pioneering studies, which showed that an emotional facial display creates a larger geometric form. Bassili placed luminescent dots on people's faces in a dark room and asked them to assume first an angry and then a happy expression. In the happy display, a burst of points of light expanded outward to form a rounded shape, while in the angry display the points of light imploded downward and inward to form a V-shaped angle. Additional data, using schematic faces, further confirmed that V-shaped images are perceived as being more negative (Lundqvist, Esteves, & Öhman, 1999), even when presented without any other facial features (Lundqvist, Esteves, & Öhman, 2004). More recent work further indicates that images containing sharp angles, including both real and abstract objects, are perceived as less preferable than comparison curved objects (Bar & Neta, 2006). Thus, a substantial set of studies provides evidence that nonrepresentational geometric shapes are appraised as conveying the emotional meaning of anger and happiness.

Furthermore, separate lines of research indicate that stimuli that signal potential threat, including angry faces, more readily capture attention (for review see Mogg & Bradley, 1999; Williams, Watts, MacLeod, & Mathews, 1997). The existence of simple, easily detectable representations of potential threat is consistent with Darwin's (1872/1998) suggestion that speedy detection of threat confers an evolutionary advantage (cf. Niedenthal & Kitayama, 1994). Numerous studies have found facilitated detection of threat-related, compared with neutral and, in some cases, pleasant stimuli

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(Eastwood, Smilek, & Merikle, 2001; Fenske & Eastwood, 2003; Öhman, Flykt, & Esteves, 2001). One commonly used method, the visual search paradigm, has been used by a number of investigators to examine this question, particularly for the detection of angry faces. In a pioneering study that has had lasting impact, Hansen and Hansen (1988) found that searching for an angry face in a happy crowd was more efficient than searching for a happy face in an angry crowd. Subsequent work using schematic faces has confirmed that angry faces consistently lead to briefer search times (Eastwood et al., 2001; Fox et al., 2000; Lundqvist & Öhman, 2005; Öhman, Lundqvist, & Esteves, 2001; Tipples, Atkinson, & Young, 2002; M. A. Williams, Moss, Bradshaw, & Mattingley, 2005). In replicating this angry-face search advantage, Horstmann and Bauland (2006) further demonstrated that isolating specific facial features fostered even greater facilitation of attention to threat-related facial cues, suggesting that simple stimulus properties are sufficient and potentially preferable for detection of threat. Of note for the present work, Horstmann, Borgstedt, and Heumann (2006) found that this effect is present simple primary nonrepresentational figures.

In addition to the rapid capture of attention, threat-related stimuli also appear to lead to difficulty in the disengagement of attention. Threat-related stimuli have been found to disrupt and slow performance of an ongoing cognitive task (Eastwood, Smilek, & Merikle, 2003; Vuilleumier, Armony, Driver, & Dolan, 2001; White, 1996), which may be a function of sustained capture of attention by the affective stimulus. Furthermore, both healthy (Koster, Crombez, Vershuere, & De Houwer, 2004) and trait anxious individuals (Salemink, van den Hout, & Kindt, in press) show difficulty disengaging attention from aversive stimuli in a dot probe paradigm. In light of these findings, it is possible that the downward-pointing V shape may not only facilitate rapid engagement of attention, but may elicit sustained attention as well.

Current Study

Taking these lines of research together, we sought to examine whether certain geometric shapes carry meaning that confers an advantage for detection. In reviewing potential confounds in the visual search literature, Purcell (1996) highlighted the importance of creating stimuli that do not create search advantages simply based on low-level visual features. Based on the fact that robust differences in affective evaluations (i.e., semantic differential scales) are associated with simple geometric shapes, we sought to examine whether visual search was preferential for the most simple, least-confounded stimuli possible. Furthermore, as discussed earlier, extensive research has underscored the ability of angry faces, schematic angry faces, and other threatening stimuli to capture attention; however, the degree to which this simple context-free shape, the downward-pointing V, exhibits similar effects has received little attention. In a preliminary experiment, we first sought to replicate previous findings and confirm whether the downward V shape stimuli selected for the capture of attention task were indeed perceived as aversive (referred to below as the "Subjective Ratings Experiment"). In a subsequent series of five visual search studies, we examined the speed and accuracy of detection of a simple geometric form representing threat, compared with those previously found to be less threatening, in order to discover whether the simplest possible visual configuration of threat would capture attention more readily than neutral comparison figures. Specifically, we predicted that figures containing a downward-pointing V angle would be detected more rapidly and more accurately than other figures, including the same shape in a different orientation (pointing upward). We further sought to explore the degree to which this shape also elicited sustained capture of attention.

Subjects viewed 4 × 4 matrices and were asked to determine whether or not the matrix contained one shape that was discrepant from the rest. In each of the first three experiments, four types of matrices were presented: all threat shapes, all nonthreat shapes, a lone threat shape embedded in a field of nonthreat shapes, and a lone nonthreat shape embedded in a field of threat-related shapes. The following threat versus nonthreat stimuli were used: Experiment 1 contrasted downward-pointing V's with upward-pointing V's; Experiment 2 contrasted downward-facing and upward-facing triangles; and Experiment 3 contrasted downward-facing triangles with circles (see Figures 1–4 for examples of stimuli). The triangles used in Experiments 2 and 3 were used to control for the fact that a downward-pointing V is a letter, and thus may be recognized more easily as a function of its familiarity rather than its geometric or threat-related properties. Experiment 4 was included as a follow-up to Experiment 3 to determine whether any triangle is detected more rapidly than a circle, or if the orientation of the triangle (up- or downward-pointing) is the crucial element; thus, upward-pointing triangles were contrasted with circles. Finally, to determine whether downward-pointing V shapes more effectively capture attention than upward-pointing V's when compared against the same distractor, in Experiment 5 we presented both of these shapes against a background of circles. Across experiments, difficulty disengaging attention was also examined, with slower responses to homogenous fields of all downward-pointing V's reflecting sustained capture of attention by that shape.

Method

Participants

Participants in all six experiments were undergraduates from the introductory psychology subject pool. The participant characteristics of the final samples for each of the experiments were as follows: Subjective Ratings Experiment: $N = 36$ participants (8 M, 28 F; mean age = 19.53); Experiment 1: $N = 30$ participants (11 M, 19 F; mean age = 19.53); Experiment 2: $N = 27$ participants (5 M, 22 F; mean age = 19.19); Experiment 3: $N = 37$ participants (8 M, 29 F; mean age = 19.05); Experiment 4: $N = 26$ participants (2 M, 24 F; mean age = 19.08) and Experiment 5: $N = 43$ (9 M, 34 F; mean age = 19.42). Due to corrupted data files, three subjects were dropped from Experiment 1, two from Experiment 2, and two from Experiment 5.

Procedures and Design: Subjective Rating Study

After obtaining informed consent, subjects were given a packet depicting one shape on each page, including a downward-pointing triangle, an upward-pointing triangle, and a circle. Beneath each shape was a seven-point bipolar semantic differential scale asking the subject to rate each shape on the following dimensions: bad-good, unpleasant-pleasant, unfriendly–friendly, kind-cruel. Lower numbers reflect more negative ratings.

Procedures and Design: Visual Search Studies

After obtaining informed consent, subjects were seated in front of a computer to complete the task. The visual search task in all five studies was the same, to determine whether or not a discrepant stimulus was present or not for each matrix. Participants viewed a series of 4 × 4 matrices containing one or two types of geometric shapes, as described above (also see Figures 1–3). In Experiment 5, three shapes were contrasted (downward- and upward-pointing triangles, circles; see Figure 4). The matrix as a whole measured 25 cm wide and 26.5 cm tall, each individual box measured 6.25 cm wide by 6.63 cm tall, and each shape was 3.13 cm wide by 3.31 cm tall. Each trial began with the presentation of a small fixation cross displayed in the center of the computer screen for 800 ms. This was followed by the matrix presented for 2000 ms, during which time a response was to be made using the keyboard. Participants were to press the “Z” key if all the shapes were identical and the key containing the “?” if one of them was different. Instructions encouraged fast and accurate responding. An intertrial interval, consisting of a blank screen, of 2000 ms followed each matrix. Experiments 1–4 included 256 trials, 64 of each type of matrix presented in a random order. Trials were presented in four blocks of 16 matrices of each type presented in each block. Discrepant shapes of both types appeared once in every location of the matrix in each block. For Experiment 5, in which we contrasted downward- and upward-pointing triangles with circles in the same design, a total of 224 trials were presented, 32 of each matrix type (downward triangle on circle, upward triangle on circle, circle on downward triangle, circle on upward triangle, all downward triangles, all upward triangles, all circles). Again, four blocks were presented, each including 56 trials. Discrepant shapes appeared in each of the 16 cells on two occasions across the four blocks.

Data Reduction and Analysis

The composite subjective ratings score across the four semantic differential dimensions was used as the dependent variable in a one-way repeated measures analysis of variance (ANOVA) with three levels (downward triangle, upward triangle, circle).

For the visual search studies, two dependent measures were assessed, reaction time (RT) and percent correct. For RT, only trials with correct responses were used. Trials for which the RT was greater than 3 *SD* from the mean for each subject were also excluded from further analysis. Mean RT and percent correct for each of the four matrix types was computed for each block.

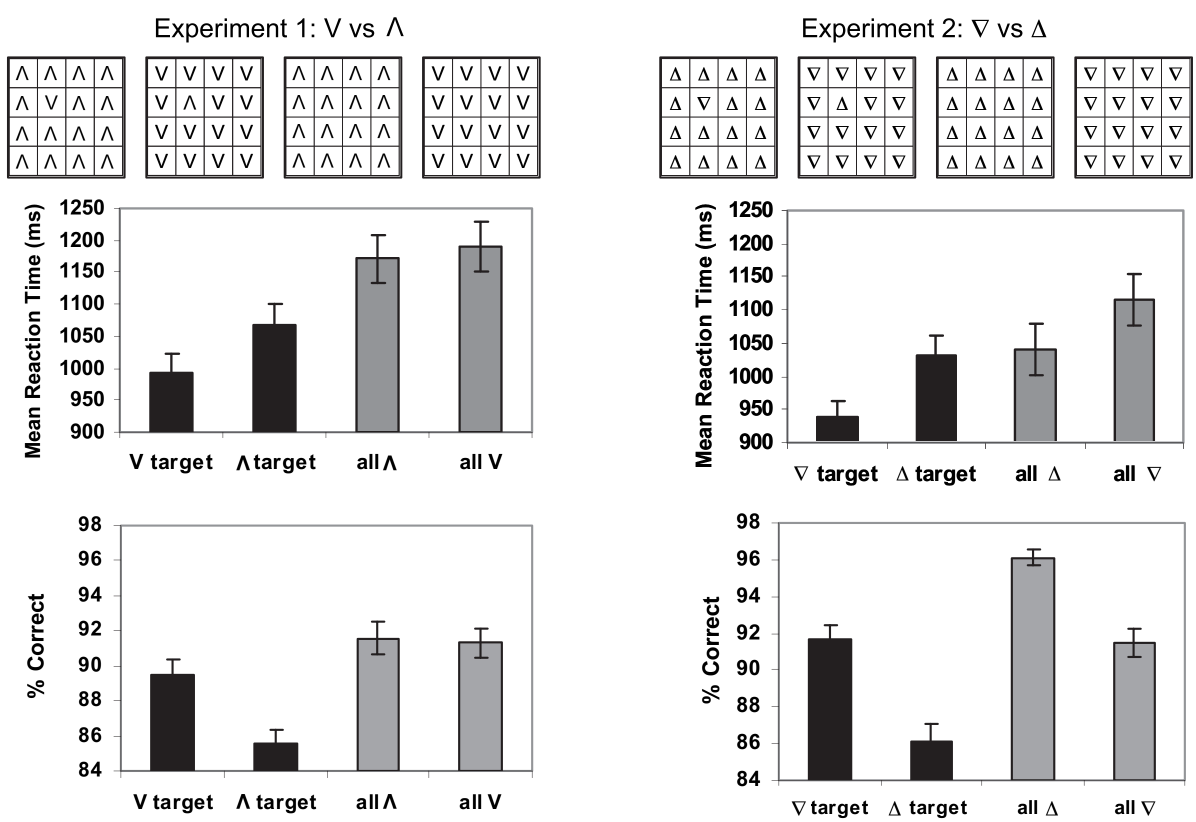

Figure 1. Summary of the stimuli and data for Experiments 1 and 2 in which figures containing downward-pointing V’s are contrasted with those containing inverted V’s. The top row depicts the four types of matrices presented in each experiment, two with a discrepant target and two without. Beneath the example stimuli are bar graphs presenting mean RT and percent of correct trials (with standard error bars) for all four matrix types in Experiments 1 and 2. Scores represent mean RT averaged across all four blocks.

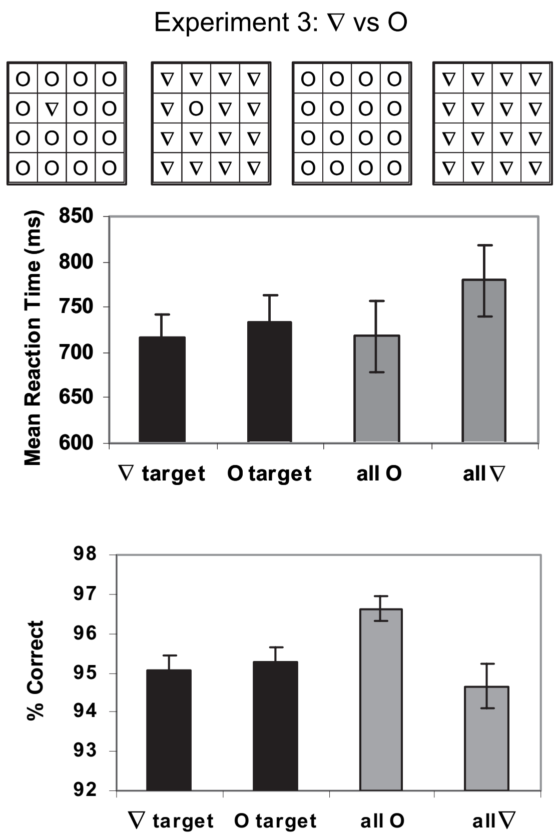

Figure 2. Summary of the stimuli and data for Experiment 3 in which figures containing downward-pointing V's are contrasted with circles. The top row depicts the four types of matrices presented in each experiment, two with a discrepant target and two without. Beneath the example stimuli are bar graphs presenting mean RT and percent of correct trials (with standard error bars) for all four matrix types. Scores represent mean RT averaged across all four blocks.

For Experiments 1–4, a Huyhn-Feldt corrected (Huynh & Feldt, 1970) repeated measures 4 × 4 ANOVA, with Matrix (4 levels: 2 with a discrepant, 2 without) and Block (1–4) as factors, was calculated separately for the two dependent variables. Due to the more complicated design of Experiment 5 in which both types of triangles were contrasted with circles, we slightly altered the analysis procedures. For both RT and accuracy, we conducted two separate Matrix X Block (1–4) repeated measures ANOVAs, one for the discrepant matrices and another for the homogenous field matrices. The discrepant matrix ANOVAs had four levels (downward triangle on circle, upward triangle on circle, circle on downward triangle, and circle on upward triangle). The homogenous field ANOVAs contained three levels (all downward triangles, all upward triangles, all circles).

Because the results for Block are of less theoretical interest for the present study, they are presented in a footnote to streamline presentation of the results for the five studies.[1] Post hoc comparisons were performed using a Bonferroni adjustment for multiple comparisons. Planned contrasts were calculated between the threat-related discrepant shapes (downward V, downward triangle) and nonthreat discrepant shapes (upward V, upward triangle, circle) in Experiments 1–3 and 5.

Results

Subjective Rating Study: Are Simple Downward-Pointing V Shapes Perceived as More Aversive?

There was a significant main effect for shape, $F(2, 70) = 41.26$, $p < .001$, $\eta^2 = 0.54$, with Bonferroni post hoc comparisons indicating a significant difference in subjective ratings between all three shapes (all p values $<.001$). In a stepwise fashion, downward-pointing triangles ($M = 3.54$, $SD = 1.00$) were rated as more aversive than upward-pointing triangles ($M = 4.57$, $SD = 0.99$), which were in turn rated as more aversive than circles ($M = 5.60$, $SD = 0.82$; lower numbers reflect a more negative rating).

Experiment 1: Are Downward-Pointing V's Detected More Rapidly and More Accurately Than Upward-Pointing V's?

RT. The ANOVA revealed a significant main effect for Matrix (downward V discrepant shape, upward V discrepant shape, all upward V's, all downward V's), $F(3, 87) = 50.26$, $p < .001$, $\eta^2 = 0.63$. As predicted, a planned comparison indicated that RTs were faster for downward V target trials compared with upward V discrepant trials, $t(29) = 7.18$, $p < .001$ (see Figure 1, Experiment 1). Based on post hoc comparisons, both types of discrepant trials were also detected faster than both nontarget trials, $p < .001$. Trials of all downward V trials did not significantly differ from trials of all upward V's, $p = .20$.

Percent correct. Similar to the results for RT, the ANOVA for percent correct also yielded a significant main effect for Matrix, $F(3, 87) = 9.70$, $p < .001$, $\eta^2 = 0.25$ (see Figure 1, Experiment 1). Our hypothesis that downward V targets would be detected more accurately than upward V targets was confirmed, $t(29) = 3.31$, $p = .002$. Matrices containing an inverted V discrepant item were detected less accurately than all other trial types, $p < .001$.

To summarize Experiment 1, as we predicted, downward-pointing V discrepant items were detected more quickly and with greater accuracy than inverted V's.

[1] For all five experiments, there was a significant main effect for Block for both RT and percent correct data. For all experiments, responses were slower for all conditions during the first block compared with all other blocks, all p values $< .001$. Similarly, responses across all conditions were less accurate for Block 1 than for all other blocks, $p < .05$.

With respect to the Matrix × Block interaction, for RT data, this interaction was not significant for Experiments 1, 2, 4, or 5, $p > .35$. For Experiment 3, the Matrix × Block interaction was significant, $F(9, 270) = 3.3$, $p = .002$, $\eta^2 = 0.10$, and indicated that the rapid detection of downward-pointing triangle targets compared to circle targets was largely due to faster detection during Blocks 2 and 3. For the percent correct data, none of the five experiments yielded a significant Matrix × Block interaction, $p > .17$.

In addition to the Matrix × Block ANOVA presented here, the data were analyzed to explore the effect of the position of the discrepant within the matrix. Across the five studies, some position effects were found. However, these were not consistent across experiments and did not alter the interpretation of the main findings presented here. These data are available upon request.

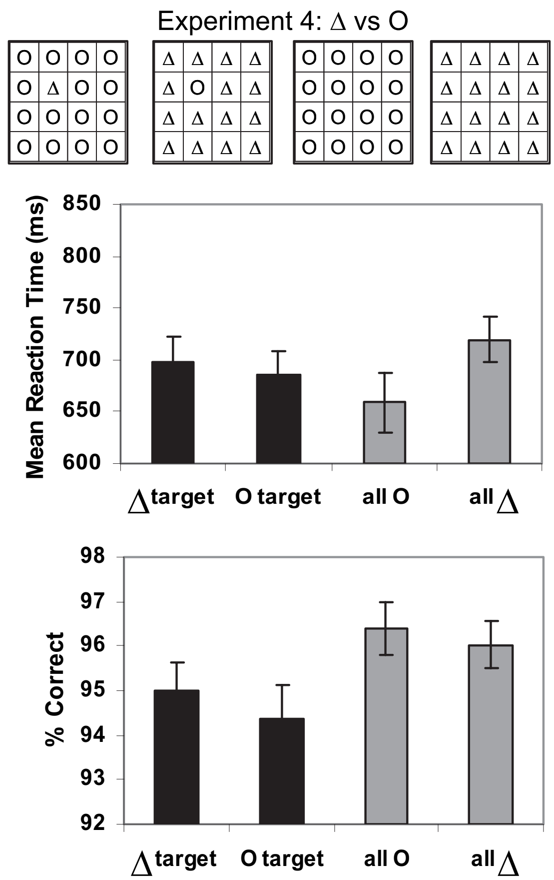

Figure 3. Summary of the stimuli and data for Experiment 4 in which figures containing inverted V's are contrasted with circles as a control for Experiment 3. The top row depicts the four types of matrices presented in each experiment, two with a discrepant target and two without. Beneath the example stimuli are bar graphs presenting mean RT and percent of correct trials (with standard error bars) for all four matrix types. Scores represent mean RT averaged across all four blocks.

Experiment 2: Is the More Rapid and Accurate Detection of Downward-Pointing V's in Experiment 1 Due to the Fact That "V" Is a Letter?

RT. Replicating Experiment 1, there was a significant main effect for Matrix (downward triangle discrepant shape, upward triangle discrepant shape, all upward triangles, all downward triangles), $F(3, 78) = 20.92$, $p < .001$, $\eta^2 = 0.45$ (see Figure 1, Experiment 2). The planned contrast between downward and upward triangle discrepant trials again indicated that downward triangles were detected more quickly than upward triangle discrepant items, $t(26) = 8.31$, $p < .001$. Both types of discrepant trials and the all upward triangle matrices were detected more rapidly than all downward triangle matrices, $p < .002$.

Percent correct. The analogous ANOVA for percent correct also yielded a significant main effect for Matrix, $F(3, 78) = 19.32$, $p < .001$, $\eta^2 = 0.43$ (see Figure 1, Experiment 2). As was the case in Experiment 1, downward-pointing triangle discrepant items were detected more accurately than upward-pointing V discrepant items, $t(26) = 4.51$, $p < .001$. Accuracy was significantly worse for upward triangle discrepant trials compared to all other trial types, $p < .001$. Trials consisting of all upward triangles were more accurately identified than all other trial types, $p < .001$. There was no difference between downward triangle target and all downward triangle trials.

Confirming the findings from Experiment 1, we again observed greater accuracy and more rapid detection of discrepant shapes containing a downward-pointing V. Thus, the search advantage for downward-pointing V's observed in Experiment 1 does not seem to be due to the fact that the downward-pointing V is a letter. In addition to this finding, participants were slower to determine that matrices filled with all downward-pointing V's did not contain a discrepant item than when viewing a field of all upward-pointing V's.

Experiment 3: Are Downward-Pointing V's Detected More Rapidly and Accurately Than Other Simple Shapes?

RT. Once again, the ANOVA revealed the expected main effect for Matrix (downward triangle discrepant shape, circle discrepant shape, all downward triangles, all circles), $F(3, 90) = 11.25$, $p < .001$, $\eta^2 = 0.27$ (see Figure 2). Similarly, the planned contrast comparing downward triangle discrepant matrices to circle discrepant matrices indicated faster responses to downward triangle targets, $t(30) = 2.25$, $p = .03$. Consistent with the data from Experiment 2, based on post hoc comparisons, all downward triangle trials were found to be detected slower than all other trial types, $p < .001$.

Percent correct. For percent correct, the main effect for Matrix was marginally significant, $F(3, 90) = 2.62$, $p < .07$, $\eta^2 = 0.08$, and the planned contrast between downward triangle and circle target trials was not significant, $p > .75$ (see Figure 2).

In sum, we again saw a speed advantage for detection of these discrepant shapes, although no accuracy advantage was present for downward-pointing triangle discrepant items.

Experiment 4: Are All Triangles Detected More Rapidly Than Other Simple Shapes, or Does the Orientation of the Triangle Matter?

RT. The ANOVA yielded a significant main effect for Matrix (upward triangle target, circle target, all upward triangles, all circles), $F(3, 75) = 9.84$, $p < .001$, $\eta^2 = 0.282$, with post hoc comparisons indicating that trials of all circles were detected more rapidly than all other trial types, *p*s $< .004$, except the trials in which circles were targets, $p > .20$ (see Figure 3). Of importance, there was no difference between upward triangle targets and circle targets, $p > .70$, indicating that rapid detection of triangles is not inherent to the shape itself, but to its downward orientation (see Experiments 2 and 3).

Percent correct. The significant main effect for Matrix, $F(3, 75) = 3.10$, $p = .03$, $\eta^2 = 0.11$, indicated that accuracy was worse for both types of target trials than for all upward triangle trials, $p < .05$ (uncorrected); however, this effect did not remain significant after Bonferroni correction.

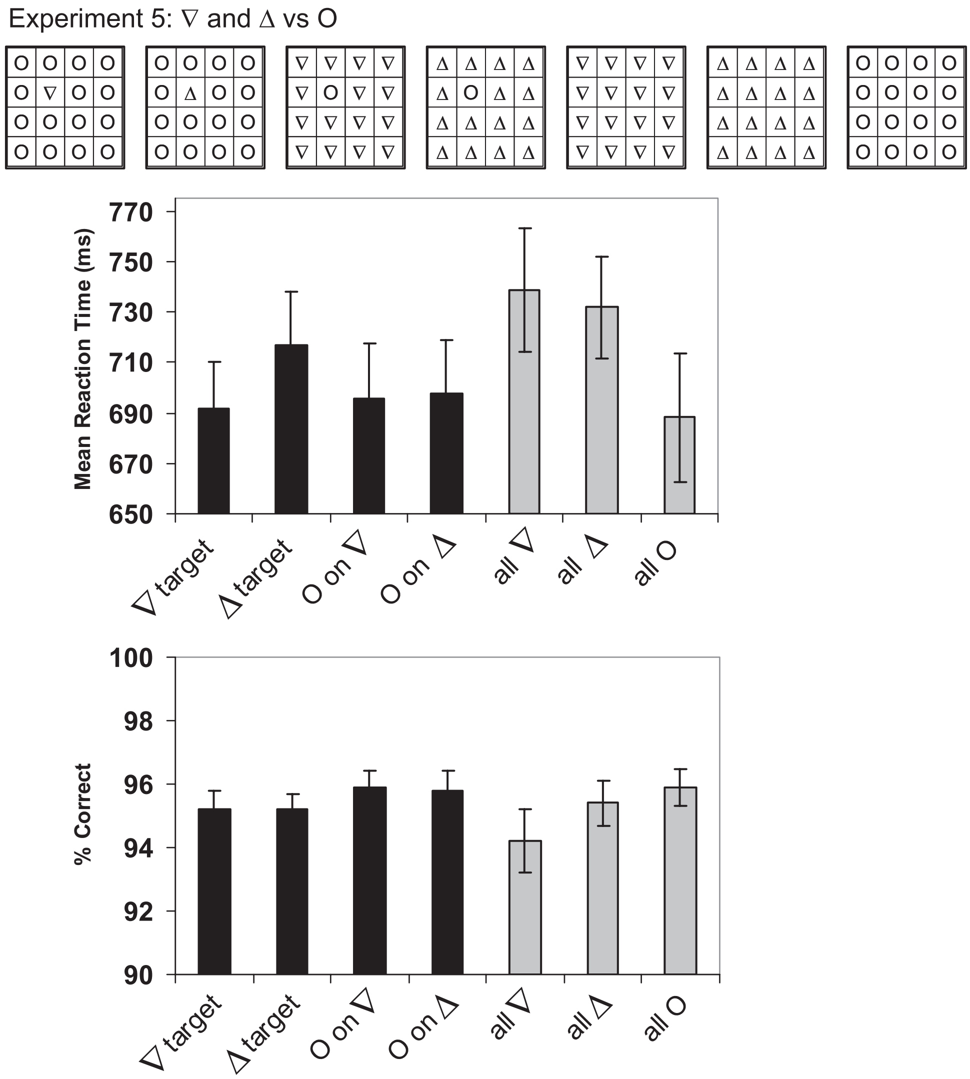

Figure 4. Summary of the stimuli and data for Experiment 5 in which both downward- and upward-pointing triangles were compared against circle distractors in the same experiment. The top row depicts the seven types of matrices presented in each experiment, four with a discrepant target and three without. Beneath the example stimuli are bar graphs presenting mean RT and percent of correct trials (with standard error bars) for all matrix types. Scores represent mean RT averaged across all four blocks.

Experiment 5: Does the Search Advantage for Downward Compared With Upward-Pointing Triangles Remain Intact When Compared Against the Same Distractor?

RT. The ANOVA on the four matrices with discrepant items revealed a significant main effect for Matrix (downward triangle on circles, upward triangle on circles, circle on downward triangles, circle on upward triangles), $F(3, 123) = 4.45$, $p = .007$, $\eta^2 = 0.098$ (see Figure 4). Consistent with the results from previous studies, and confirming the notion that the downward orientation of the V angle is crucial for faster search speeds, downward-pointing discrepant triangles were detected more rapidly than upward discrepant triangles, $t(41) = 3.45$, $p < .001$. None of the other contrasts was statistically significant, $p > .12$. A significant main effect for Matrix was also found for the matrices containing no discrepant items (all downward triangles, all upward triangles, all circles), $F(2, 82) = 18.68$, $p < .001$, $\eta^2 = 0.313$, with post hoc comparisons indicating that trials of all circles were detected more rapidly than both all triangle matrices, $p < .001$ (see Figure 4). RTs for all downward and upward triangle matrices did not differ from each other, $p = .99$. Thus, in the context of the present experiment, determining that a field of circles contains no discrepant items appears to be a simpler task than making the same judgment for homogenous fields of triangles.

Percent correct. There was no significant main effect of Matrix for either the ANOVA comparing the four matrices with discrepant items, $F(3, 123) < 1.00$, or the ANOVA comparing the three matrices without discrepant items, $F(2, 82) = 1.89$, $p = .18$. Trials with discrepant items were detected equally as accurately as those without, $t(41) < 1.00$.

Discussion

In contrast to the extensive body of work examining the muscular activity of the face associated with the expression of emotion, there is much less clarity about the mechanisms through which emotion displays are recognized. A meticulously detailed coding system, the Facial Action Coding System, developed by Ekman, Friesen, and Hager (2002), categorizes the exact movements of the muscles (action units or AU) of the human face that move facial features into the positions associated with the different emotions. A theory of the universal expression of emotion displays, such as Ekman's (2003), presumes that there is a parallel neural substrate of feature detectors that recognize a facial expression, a mechanism which Ekman helpfully terms the "autoappraiser." But it is not yet clear just what sign-stimuli are used to recognize an emotion display. It would be enormously inefficient if the brain provided a feature detector to respond to each AU, and only somewhat less inefficient to provide a feature detector for each movement of the most prominent facial landmarks, such as the position of the eyebrows, the shape of the mouth, the visibility of the teeth, or the shape of the chin. But it would be extremely efficient if there were feature detectors to recognize the larger facial configurations of "imploding V-shaped" and "expanding round" configural stimuli, such as those that Bassili (1978, 1979) showed were associated with the expression of anger and happiness, respectively.

The experiments reported here show quite clearly that minimal stimulus configurations, related to the ones that Bassili identified in facial expressions, affect the capture and maintenance of attention, just as they affect the semantic meaning attributed to the stimuli. Results showed that in Experiments 1–3 and 5, the detection of a discrepant stimulus was more rapid for a threat-related shape (downward-pointing V or triangle) than a nonthreat-related shape (upward-pointing V or triangle, or circle). Of importance, the data from Experiments 4 and 5 highlight the specificity of this facilitated detection; when the exact same shape, a downward-pointing triangle, is compared with an upward-pointing triangle, the speed of detection is more rapid for the triangle with the downward orientation. Thus, very simple, nonrepresentational, geometric threat-related stimuli captured attention more rapidly, as they did in previous work with clearly threatening stimuli. In addition, the slower RTs for the all-threat fields (downward-pointing triangles) in Experiments 2 and 3, suggest that there is also greater difficulty disengaging attention from this simple threat-related stimulus. It is unclear why this effect was not evident in Experiment 1 or 5; however, given the slower overall reaction times for Experiment 1 it is possible that the greater difficulty of this search task led to a ceiling effect. In contrast, for Experiment 5, the ease of detection of all circle trials may have altered search strategies for the triangle trials leading to a lack of difference between the different triangle types. Future work will need to examine the effects of search difficulty on speed of detection for the all-threat fields. In sum, the results of these experiments indicate that the nature of the feature detector mechanisms inherent in the neural substrates of threat detection might be highly specific and highly efficient.

In comparing these results with those of other researchers, we need to recognize that one previous visual search study compared the search for threatening and nonthreatening eyebrow-shaped stimuli (very similar to the V shape used in our Experiment 1) and failed to find facilitated search for threatening eyebrows unless they were embedded in a schematic face or the outline of a face (Tipples et al., 2002). Our stimuli differed in three ways from Tipples and colleagues: first, the eyebrow shaped stimuli in the Tipples study did not meet at the vertex as did ours; second, the angle of the lines was more acute in the present study; and third they used a 3×3 grid, whereas we used a 4×4 grid. Thus, one possible reason for the discrepancy between the two findings may lie with the characteristics of the "V" shape itself; perhaps a sharper angle, with a clear "V" present (due to the lines meeting at the vertex) is a more potent aversive stimulus. As we did not directly compare these shapes in this study, this explanation is purely speculative and deserves further attention. With respect to the overall task, it is also possible that in a 3×3 grid the search for a discrepant stimulus is a less difficult discrimination, and thus results in a RT floor effect. This assertion is consistent with the results of another visual search study conducted by Tipples and colleagues (Tipples, Young, Quinlan, Broks, & Ellis, 2002) in which they found that increasing the set size amplified the RT differences in the search for threatening compared to neutral targets. Thus, the larger set size used in our paradigm may have been more sensitive to differences between conditions.

Batty and colleagues (Batty, Cave, & Pauli, 2005) suggested that emotion-based models of facilitated search for threat could not explain the "pop-out" effect for threatening stimuli; rather they advocated a visual attention model emphasizing the role of simple visual features in the targets compared with the distractors. Indeed, they stated, "Threat stimuli could be found easily in search. . . only if there were simple visual features that appeared more often in threat targets than in nonthreat distractors" (p. 419). Although the present set of experiments cannot provide a true test of the pop-out effect itself, as set size was not manipulated, these data can shed light on the degree to which capture of attention is more generally a function of simple stimulus features or the affective properties of the stimuli. In Experiments 1 and 2, the stimulus properties of the target and distractor were tightly controlled; the shape used was identical, a triangle or an open V—they only differed in orientation. By eliminating this confound in stimulus features, we were able to demonstrate that this difference in orientation was crucial for determining speed of detection as well as attentional disengagement. Given the current and previous work associating the downward-pointing V with negative subjective emotional ratings, the facilitated search found here is likely due to affective rather than perceptual features of the stimulus.

Although the data from the present studies demonstrate a clear attentional advantage for simple shapes containing a downward-pointing V, it is important to acknowledge that at a certain point contextual cues may override the advantage conferred by this context-free shape. As an example, Öhman and colleagues (Öhman, Lundqvist, and Esteves, 2001) found that the search advantage for angry schematic faces was retained when the faces were inverted. In this paradigm, the downward-V angle of the eyebrows becomes an upward-pointing V. From the perspective of the present findings, if the downward-pointing V shape were the overriding determinant of attentional capture then the facilitation of visual search should be attenuated rather than retained in response to these inverted faces. In this case though, the contextual information offered by the gestalt presentation of the angry expression may obscure the effects of the simple V shape and cue rapid engagement of threat. Future work, such as that building on the studies of Horstmann and colleagues (2006), is needed to examine the degree to which the downward V angle enhances attention in the face of other competing contextual cues.

In addition to the rapid detection of downward-pointing V targets, in two experiments these shapes also led to slower responses in the trials when no target was present, suggesting difficulty disengaging attention from these figures. These data are consistent with others demonstrating difficulty disengaging attention from threat-related stimuli in a variety of tasks, including the visual search paradigm (Brosch & Sharma, 2005), a spatial cueing and inhibition of return task (Fox, Russo, & Dutton, 2002), and the dot probe paradigm (Koster et al., 2004). Not only do these data indicate a delayed disengagement of attention for the all-V trials, but they may also suggest that slower detection of target shapes in a field of downward-pointing V distractors may be due to difficulty disengaging attention from these shapes, rather than speeding detection when these shapes are the target. This effect was, however, less consistent across studies than the search advantage for trials containing downward V discrepant shapes, suggesting that sustained capture of attention by this shape may be more influenced by the nature of the search task than is rapid capture of attention.

Of importance, as demonstrated by the current work, the capture and maintenance of threat-oriented attention is evident even for this very simple geometric representation of threat. The fact that facilitated search is present for the same stimulus when presented in the downward orientation, but not the inverse, provides strong evidence that this difference is not merely a function of the number of features shared by target and distractors. As with many previous studies, these data suggest that emotional information takes precedence and is processed preferentially (Vuilleumier, 2005). Taken together with work presented here and previously indicating that these shapes are perceived as more threatening, the current data suggest that the essence of threat can be conveyed with minimal nonrepresentational stimulus detail.

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