

University of Warwick institutional repository: <http://go.warwick.ac.uk/wrap>

This paper is made available online in accordance with publisher policies. Please scroll down to view the document itself. Please refer to the repository record for this item and our policy information available from the repository home page for further information.

To see the final version of this paper please visit the publisher's website. Access to the published version may require a subscription.

Author(s): Derrick G. Watson, Elisabeth Blagrove & Sally Selwood  
Article Title: Emotional triangles: A test of emotion-based attentional capture by simple geometric shapes  
Year of publication: 2011

Link to published article:

<http://dx.doi.org/10.1080/02699931.2010.525861>

Publisher statement: This is an electronic version of an article published in Emotional triangles: A test of emotion-based attentional capture by simple geometric shapes. Derrick G. Watson, Elisabeth Blagrove, Sally Selwood. *Cognition & Emotion* Vol. 25, Iss. 7. *Cognition & Emotion* is available online at: <http://www.tandfonline.com/toc/pcem20/25/7>

Emotional triangles: A test of emotion-based attentional capture by  
simple geometric shapes

Derrick G. Watson

Elisabeth Blagrove

and

Sally Selwood

University of Warwick, UK

Address for correspondence:

Derrick G. Watson

Department of Psychology

University of Warwick

Coventry CV4 7AL

UK

Telephone: +44 (0)2476 522763

Email: [d.g.watson@warwick.ac.uk](mailto:d.g.watson@warwick.ac.uk)

Keywords: visual search, emotion, face processing, expression, attentional capture

### **Abstract**

Previous work has proposed that simple geometric shapes, carrying the features present within negative or threatening faces are especially effective at capturing or guiding attention. Here we test this account and provide converging evidence for a threat-based attentional advantage. Experiment 1 found that downwards pointing triangles continue to be detected more efficiently than upwards pointing triangles when: (i) both overall RT and search slope measures are obtained, and (ii) when the set size is varied and the stimuli are presented in random configurations. Experiment 2 tested and ruled out an alternative account of the selection advantage, based on differences between triangle shape consistencies with scene perspective cues. Overall, the data provide converging evidence that simple geometric shapes, which might be particularly important in providing emotional signals in faces, can also attract attention preferentially even when presented outside of a face context.

## **Introduction**

Given the overwhelming amount of visual information that reaches our senses, we need effective mechanisms that filter out irrelevant information and give priority to that which might be most important for our survival and behavioral efficiency. For example, previous work has shown that our attention is automatically captured by behaviorally important stimuli and events such as the appearance of new objects (e.g., Davoli, Suszko & Abrams, 2007; Yantis & Jonides, 1984; Yantis & Hillstrom, 1994) and that this capture can be enhanced by the observer's goals and intentions (e.g., Watson & Humphreys, 1997, 1998). In addition to such new object-based capture of attention, recent work has shown that certain stimulus shapes that convey important emotional information can also preferentially capture and hold attention. For example, compared with other stimuli, faces appear to constitute a highly salient set of stimuli supporting rapid and efficient detection both within and beyond the current focus of attentional processing (e.g., Calvo & Esteves, 2005; Johnson, 2005; Vuilleumier, Armony, Driver & Dolan, 2001; see Palermo & Rhodes, 2007, for a review). This preferential processing of faces holds across a wide range of facial representations ranging from realistic photographic faces to simple line drawings or schematic representations (e.g., Sagiv & Bentin, 2001; Wright et al., 2002; Kanwisher, McDermott & Chun, 1997).

It is also apparent that within the general class of face stimuli, different faces can be preferentially processed depending upon their emotional expression. In particular, faces showing negative or threatening expressions (e.g., sad, angry or fearful) are detected in visual search tasks more rapidly than positive or non-threat faces (e.g., Tipples, Atkinson & Young, 2002; Blagrove & Watson, 2010; Eastwood, Smilek &

Merikle, 2001; Williams, Moss, Bradshaw & Mattingley, 2005), leading to faster overall RTs and shallower search slopes (the RT-set size function). Indeed, a negative face detection advantage has been shown using a wide range of methodologies including; flanker interference (Fenske & Eastwood, 2003), cueing tasks (Fox, Russo, Bowles & Dutton, 2001; Georgiou, Bleakley, Hayward, Russo, Dutton, Eltiti & Fox, 2005), and visual enumeration (Eastwood, Smilek & Merikle, 2003). In addition to being detected more efficiently, some studies also suggest that it might be more difficult to disengage attention from a threatening stimulus (Fox et al., 2001; Georgiou et al., 2005). Such a selection advantage for negative or threatening stimuli, and their enhanced ability to hold our attention, has clear ecological advantages in terms of providing the earliest possible detection of potentially harmful stimuli over other less relevant stimuli within the environment (but see also; White, 1995; Juth, Lundqvist, Karlsson, & Öhman, 2005; Williams et al., 2005 for failures to find visual search threat-related object advantages in some situations).

Recently, Larson, Aronoff and Stearns (2007) sought to determine whether the simplest of geometric shapes that might convey emotional content would lead to differential processing. Over a series of five experiments, they found that the detection of a V-shape or downwards pointing triangle (supposedly conveying a negative emotion) was faster than the detection of an inverted V or upwards pointing triangle when presented amongst various other geometric distractor shapes (e.g., a V target amongst O distractors). In addition, in some conditions, responses were slower when the field consisted of threat-related shapes only (i.e. on target absent trials), suggesting that it was more difficult to disengage attention from such shapes. Larson et al., concluded that these

simple geometric shapes could convey emotional signals, capturing and holding attention even when not embedded within a face context.

Similarly in an earlier study, Tipples et al., (2002) found a detection advantage for faces containing V-shaped eyebrows (designated scheming or angry faces), compared with faces containing inverted V-shaped eyebrows (associated with more positive expressions). However, when these simple features were presented in a non-face context (e.g., when presented in an outline rectangle, or when some of the internal features of the face were removed), then there was no advantage for stimuli containing a V-shape. Thus, Tipples et al., (2002) argued that V-shaped eyebrow shapes might drive a threat-related selection advantage only when presented as part of a face representation (see also Schubö, Gendolla, Meinecke & Abele, 2006).

Nonetheless, the discrepancy between the results of Larson et al., (2007) and Tipples et al., (2002) might have resulted from methodological differences. For example, Larson et al., suggest that the difference in results may have arisen because of (i) simple stimulus differences (the angle and sharpness of the V-shape), and/or (ii) the use of different set sizes. Specifically, Tipples et al., presented observers with 3 x 3 grids of stimuli, whereas Larson et al., used 4 x 4 grids. It was suggested that the larger set size might have had the effect of amplifying any emotion based attention capture (Tipples et al., 2002). Note however, that both the Larson et al., (2007) and Tipples et al., (2002) studies presented participants with a fixed, highly regular matrix/grid of stimuli (4 x 4 or 3 x 3 respectively) and the number of search elements (i.e. set size) was not varied (see also Schübo et al., 2006; Öhman, Lundqvist & Esteves, 2001; for examples of matrix

presentations of stimuli and Frischen, Eastwood & Smilek, 2008 for further discussion of the variation of set size in visual search with emotional faces).

One issue with this type of methodology is that it does not allow one to determine a 'search slope' as a measure of attentional capture. Typically in visual search studies, a target is presented amongst a varying number of distractor elements and search performance is most often measured by determining the effect on RTs of increasing the number of items in the display (the RT-set size function or search slope). More difficult or inefficient search tasks are indicated by steeper search slopes, and easier search tasks by shallower search slopes (see e.g., Wolfe, 1998a).

However, as Gerritsen, Frischen, Blake, Smilek and Eastwood (2008) point out, with a fixed set size one cannot dissociate the effects of attentional guidance from effects occurring after the target has been found (see also Eastwood et al., 2001, for discussion of this point). For example, it is possible that both upward and inverted triangles can be found equally efficiently (i.e. have the same search slope) but that post-detection differences in response processes then cause a difference in the overall recorded RTs. Varying the set-size and using search slopes as a measure of attentional capture/guidance removes this possibility. The use of single size matrices also makes interpretation of error rates more difficult for the same reasons. That is, errors may increase equally as a function of display size, but show an overall difference across conditions, which need not necessarily be related to the strength of attentional guidance of the different targets.

In addition, it is possible that the highly regular grids of stimuli allowed observers to use texture segmentation cues as a method of target detection, which might produce differing results to when targets have to be searched for in less regular grids in which

texture differences are not apparent (Wolfe, 1992). Thus it is possible that the efficient detection of threat-related geometric shapes reported by Larson et al., reflect response differences and/or the effects of texture segmentation, rather than differences in the ability of stimuli to guide or capture attention.

It is also possible that the downwards pointing triangle advantage reflects differences in the efficiency of detecting items that are either congruent or incongruent with the general scene perspective, rather than differences related to emotional signals. For example, a set of upward pointing (distractor) triangles could be perceived as a ground plane (e.g., a floor surface) containing rectangles extending away from the observer, with the longest (lowest) edge being closest. In this case, a downward pointing target triangle would mis-match this general scene perspective because its longest edge would be furthest away from the observer (i.e. the triangle could be perceived as 'standing up' or as being a different shape to the distractors). In contrast, with a display containing downward pointing triangles, the target would be congruent with the perspective and the distractors incongruent. It is possible that detecting a target that is congruent with the scene perspective amongst scene-incongruent distractors is more difficult than the reverse, leading to a search asymmetry (for examples of search asymmetries see e.g., Treisman & Gormican, 1988; Treisman, 1985; Treisman & Souther, 1985; see Wolfe, 2001 for an overview).

#### *Purpose of the present study*

In summary, the present study had four main aims. First, given the somewhat inconsistent results in the literature, we thought it would be valuable to attempt to replicate the findings of Larson et al. Second, we sought to eliminate some of the



potential problems inherent in the previous studies by varying the set size and presenting irregular displays. This allowed us to determine a measure of attentional capture/guidance based on search slopes and eliminated the possible influence of texture segmentation cues on target detection. Third, by varying the set size, we were able to test whether differential guidance to threat-related geometric stimuli increased as a function of set size. Finally, in Experiment 2, we tested an alternative account of the preferential capture of attention by downwards pointing triangles based on differences in perspective congruency rather than on potential differences related to emotion signals.

### **Experiment 1: Visual search for upwards and downwards pointing triangles**

Experiment 1 determined the efficiency of detecting a downward pointing target triangle (threat-related) amongst upward pointing distractor triangles (non threat-related) and vice-versa. In contrast to Larson et al., we presented displays which contained 8, 16 or 24 items in randomly arranged displays, so that there was no regular grid-like arrangement of the stimuli.

### **Method**

#### *Participants*

24 students (7 male), aged 18 to 22 years ( $M = 20.8$ ) from the University of Warwick volunteered to take part. All had normal or corrected-to-normal visual acuity.

#### *Stimuli and apparatus*

Stimuli were generated and presented by a custom Turbo Pascal computer program running under MS-DOS on a 1GHz Pentium-based PC attached to a 17-in SVGA monitor at a resolution of 800 x 600 pixels. Individual stimuli consisted of upwards and downwards pointing grey (RGB value 115, 115, 115) equilateral triangles,

with sides 9mm in length. Each visual search display was generated by randomly placing the stimuli into the cells of an invisible 8 x 8 matrix. The minimum inter-stimulus distance was approximately 15 mm (center-to-center). The positions of individual stimuli were also jittered to avoid collinear arrangements of adjacent stimuli. There were two main types of search display, i) search for a downwards pointing target amongst upwards pointing distractors, and ii) search for a downwards pointing distractor amongst upward pointing distractors (see Figure 1). The total display size was 8, 16 or 24 items and the target was present on 50% of trials. When present, the target took the place of one of the distractors.

#### *Design and procedure*

The experiment used a fully within, 2 (target: present / absent) x 2 (target type : upwards or downwards pointing triangle) x 3 (display size: 8, 16 or 24 items) design. Each block contained 120 randomly ordered trials, divided equally between the 12 combinations of target presence, target type and display size. Participants were instructed to determine whether a discrepant target was present or absent in each display, and were asked to respond as quickly as possible but without sacrificing accuracy. Each participant completed three blocks of trials, resulting in 30 trials per cell, in a single session lasting approximately 30 minutes. Directly before the first full block of trials, participants were shown a short demonstration block and completed a practice block of 24 trials.

A single trial consisted of a blank screen (500ms), followed by a central fixation square (2 mm x 2 mm, shown for 1000 ms), followed by a search display which remained until a response was made. Participants responded by pressing key Z or M to indicate the presence or absence of a target in the display. Following a trial, response errors were

indicated by the presentation of the word 'error' at the display center for 1000ms. Key assignment was counterbalanced across participants. Viewing distance was approximately 50cm, although no mechanical means were used to restrict head movements.

## Results

*Reaction times:* Mean correct RTs were calculated individually for each cell of the design for each participant. Overall mean correct RTs as a function of target presence, distractor type and display size and search slopes are shown in Figure 2. The data were analyzed using a 2 (target, present or absent) x 2 (distractor type, upward or downward pointing distractors) x 3 (display size, 8, 16, 24) within-participants ANOVA. All three main effects and their interactions proved significant. RTs were shorter on present trials than on absent trials,  $F(1,23) = 13.27$ ,  $MSE = 152073.91$ ,  $p = .001$ , were shorter overall in displays with upwards pointing distractors,  $F(1,23) = 16.97$ ,  $MSE = 19926.53$ ,  $p < .001$ , and increased as display size increased,  $F(2,46) = 51.86$ ,  $MSE = 29795.68$ ,  $p < .001$ . In addition, RTs increased more with display size on absent trials than on present trials,  $F(2,46) = 33.62$ ,  $MSE = 12007.78$ ,  $p < .001$ , and there was a larger difference between absent and present RTs with downwards pointing distractor displays than with upward pointing distractor displays,  $F(1,23) = 9.40$ ,  $MSE = 16939.33$ ,  $p = .005$ . Further, RTs increased more with display size with downward pointing distractors displays, than with upward pointing distractor displays,  $F(2,46) = 3.79$ ,  $MSE = 5100.45$ ,  $p < .05$ . The three-way interaction was also significant,  $F(2,46) = 3.84$ ,  $MSE = 4963.94$ ,  $p < .05$ . To unpack

this interaction, two additional ANOVAs were conducted individually on the absent and present trial data.

Considering absent trials alone, RTs increased with display size,  $F(2,46) = 49.38$ ,  $MSE = 35705.34$ ,  $p < .001$ . Neither the main effect of distractor type, nor its interaction with display size approached significance, both  $F_s < 1$ . On present trials, RTs increased as display size increased,  $F(2,46) = 30.43$ ,  $MSE = 6098.12$ ,  $p < .001$ . However, of most interest, RTs were shorter for downwards pointing target displays (upwards pointing distractors),  $F(1,23) = 43.28$ ,  $MSE = 11108.71$ ,  $p < .001$ , and RTs increased less with display size for downwards pointing target displays (upwards pointing distractors),  $F(2,46) = 6.67$ ,  $MSE = 5745.89$ ,  $p < .005$ . This interaction indicates that the search slope for downward pointing targets (4.2 ms/item) was shallower than for upward pointing targets (11.1 ms/item). In addition to this difference in slope, paired t-tests revealed that the downwards pointing triangle target was detected faster than the upward pointing target at all three display sizes; 8,  $t(23) = 2.85$ ,  $p < .01$ ,  $d = .248$ , 16,  $t(23) = 5.50$ ,  $p < .001$ ,  $d = .493$  and 24,  $t(23) = 5.23$ ,  $p < .001$ ,  $d = .588^1$ .

*Errors:* Mean percentage error rates are shown in Table 1. Errors were more likely on present trials than on absent trials  $F(1,23) = 71.52$ ,  $MSE = 39.91$ ,  $p < .001$ , and were greater for downwards pointing distractor displays,  $F(1,23) = 26.64$ ,  $MSE = 30.03$ ,  $p < .001$ . In addition, there was a trend for errors to increase as display size increased,  $F(2,46) = 3.02$ ,  $MSE = 20.36$ ,  $p = .059$ , and this increase was greater on present trials than on absent trials,  $F(2,46) = 11.01$ ,  $MSE = 15.36$ ,  $p < .001$ . The difference between error rates on present and absent error rates was greater for downwards pointing distractor displays  $F(1,23) = 43.50$ ,  $MSE = 29.38$ ,  $p < .001$ , and errors increased more

with display size for downward pointing distractor displays,  $F(2,46) = 5.15$ ,  $MSE = 20.79$ ,  $p = .01$ . The three-way interaction was also significant,  $F(2,46) = 3.83$ ,  $MSE = 14.63$ ,  $p < .05$ . Taking absent trials alone, no main effects or their interaction proved significant, all  $F_s < 1.56$ ,  $p_s > .223$ . On present trials, errors were greater for upward pointing targets than for downward pointing targets,  $F(1,23) = 49.35$ ,  $MSE = 41.54$ ,  $p < .001$ , and increased with display size,  $F(2,46) = 8.32$ ,  $MSE = 26.08$ ,  $p = .001$ . This increase was greater for upwards pointing targets than for downwards pointing targets,  $F(2,46) = 7.16$ ,  $MSE = 20.45$ ,  $p < .005$ .

## **Discussion**

One of the main goals of Experiment 1 was to replicate Larson et al., using displays which contained a varying number of elements, and in which the stimuli were randomly arranged. The results were clear in this respect. Searching for a downwards pointing (threat-related) triangle amongst upward pointing (non threat-related) distractors was more efficient than the reverse. This was true based on both overall RTs and based on search slope efficiency measures. Specifically, when searching for the supposedly threat-related target, RTs were shorter overall, and increased less as the number of distractors increased than when searching for a non-threat target amongst threat-related distractors. This provides a valuable replication of and an extension to Larson and colleagues' study, in that simple geometric shapes can show differences in search efficiency, even when the items are not in a regular, grid-like formation. Furthermore, not only were overall RTs shorter for the threat-related target, but also the associated search slope was shallower. Therefore, this slope-based threat advantage cannot be attributed to response effects, but suggests instead that attention was captured or guided more strongly

by the threat-related target than the non-threat stimulus. A similar pattern of results was found for the error data, indicating that RTs were not compromised by any speed-accuracy trade-off. In summary, the present results provide converging evidence that simple geometric shapes can attract attention to differing degrees, perhaps due to their association with differing emotional expressions (Larson et al., 2007; Tipples et al., 2002).

Interestingly, on absent trials, there was no reliable difference between distractor type, in terms of overall RTs, search slopes or error rates. This suggests that, with the current set of display parameters, the threat shapes did not appear to hold attention, and that displays consisting of threat stimuli only (target absent) could be searched as quickly as all non-threat (target absent) displays. In contrast, Larson et al. found that, in a subset of their experiments, RTs on all threat trials were slower than displays which contained only non-threat stimuli. Clearly, the exact conditions under which geometric shapes will produce an attentional disengagement effect need to be investigated further. Finally, we note that the difference in RTs between each target type increased as a function of display size (Tipples et al., 2002). Hence, this suggests that the effect of emotional content increases as the number of display elements increases (cf. Blagrove & Watson, 2010, who found a similar increase with valenced schematic faces, but also Öhman et al., 2001, who did not). This increase can be explained relatively easily, because as the number of possible search items increases, so too will the advantage of a target that can call attention to itself (i.e. as fewer distractors will need to be processed before the target is found). Note also that our search slopes were highly linear, indicating that the threat advantage remains relatively constant as the number of items in the display increases. Thus, it is not the case that the threat advantage becomes weaker or is diluted in

conditions of greater attentional competition. This also suggests that mechanisms enabling enhanced threat detection are robust and are attuned to their ecological purpose (Öhman & Mineka, 2001; LeDoux, 1996, 1998). That is, a system which fails when conditions become more difficult would be less adaptive than one that remains effective across a wide range of conditions.

In Experiment 2, we explore an alternative explanation for why downward pointing triangles might be especially effective at attracting attention. This account proposes that the advantage might be based on the stimuli's perspective congruency within the scene, rather than on potential differences in emotional signals.

### **Experiment 2: Testing a perspective account of the downwards pointing triangle advantage**

Previous work has suggested that the search advantage for V shapes or downward pointing triangles could be because such shapes signal negative or threatening face stimuli and such negative stimuli preferentially attract attention. Experiment 2 investigates an alternative explanation based on possible differences in perspective congruency. Typically in a visual scene, rectangles placed on the ground will form a trapezoid or triangle shape, in which the edge closest to the observer is longer than the edge that is furthest away. If we consider Figure 1B from Experiment 1, we can see that this display could be perceived as consisting of rectangles placed on the ground (i.e. the distractor set). This set of stimuli shows the correct scene perspective. The target would then be the shape which is incongruent with this general perspective view (i.e. the downward pointing triangle). In contrast, the display in Figure 1A could be perceived as

containing numerous rectangles which are incongruent with a ground-based perspective and a single target which is congruent. Thus, it is possible that the search advantage for a downwards pointing triangle is observed because it is easier to detect a single stimulus, incongruent with perspective amongst those which are congruent, compared with the reverse case. Such asymmetries in search are not uncommon. For example, it is easier to detect a Q amongst Os than the reverse, because the Q has a feature which distinguishes it from the O distractors. In contrast, search for an O amongst Qs relies on the detection of an absence of a feature (the lack of a diagonal line present in the letter Q distractors; see e.g., Wolfe, 2001; Treisman & Gormican, 1988; Treisman & Souther, 1985).

In support of this possibility, previous studies have shown that the local environment or context can influence perception. Lappin, Shelton and Rieser (2006) showed that the 3D context influenced distance judgments, finding that observers overestimated the midpoint in enclosed scenes (such as a lobby) compared with more open scene. Further illustrations come from visual search studies in which the efficiency of detecting a vertical line amongst tilted distractor lines is greatly influenced by the orientation of a surrounding outline reference frame or background context (Treisman, 1985; Doherty & Foster, 2001, for a summary see Marendaz, 1998). For example, searching for a vertical line amongst tilted lines is more difficult than the reverse task. In summary, the visual system appears particularly sensitive to detecting stimuli that deviate from a 'standard' value – in this case, being upright (Treisman, 1985; Treisman & Gormican, 1988). However, if an outline reference frame is tilted, so that it matches the distractor orientation, then search for the vertical target is now easier. In this case, the



standard value is held by the distractors, (i.e. their orientation matches the global frame orientation), and hence, the vertical target is now holds the non-standard value (Treisman, 1985). In the case of Experiment 1, it might be possible that the standard value for a stimulus is one which matches its frame of reference in terms of perceived perspective. Following this argument, the downwards pointing triangle would be easy to detect because it differed from the standard value held by the distractors, just as a tilted line differs from the standard vertical line and thus, is easy to detect.

In order to investigate this alternative 'reference frame' account, we generated displays in which we attempted to influence the perceived perspective within the displays. If perspective is effective in influencing the salience of the triangle targets, then by modifying the perspective, we should also modify (i.e. reverse) the salience of the triangle targets. We attempted to manipulate perspective by presenting two framing trapeziums; one placed at the bottom of the screen (representing the floor), and one placed at the top (representing the ceiling). The search display was then presented within the floor or the ceiling frame (see Figure 3). First, consider when the search display is presented in the floor frame (Figures 3c & 3d). Here, the downward pointing target would be incongruent with the frame of reference (i.e. would differ from the standard value) and the upward pointing target would be congruent. This would be equivalent to the display in Experiment 1 (assuming that participants perceived the display to consist of objects placed on the floor, by default). If the downward pointing target advantage was based on its inconsistency with the global perspective, then we would again expect an advantage for the downward pointing triangle target.

In contrast, consider the instance when the search display is presented in the ceiling frame of reference (Figure 3a & 3b). Now, the upwards pointing triangle would be inconsistent with the perspective (Figure 3a) and the downward pointing target would be consistent with it (Figure 3a). Accordingly, if inconsistency with the current perspective allows a target to be detected more easily then a search advantage should now be found for the upwards pointing triangle target rather than the downwards one. Thus, we would expect a downwards triangle target advantage for displays placed in the floor reference frame, but an upwards triangle advantage when displays are presented in the ceiling frame of reference. In contrast, if V-shaped targets attract attention because of their emotional connotation, then we would expect an advantage for a downwards pointing triangle irrespective of whether the display was placed in the floor or ceiling reference frame.

## **Method**

### *Participants*

Twenty four students (six male), aged 18 to 22 years ( $M = 20.4$ ) from the University of Warwick volunteered to take part. All had normal or corrected-to-normal visual acuity.

### *Stimuli and apparatus*

The stimuli were similar to those of Experiment 1, except that the search displays were presented within one of two trapeziums located at the top or the bottom of the display. For the top displays, the search elements were randomly positioned within a 10 x 4 invisible matrix with the following constraints. In the top row, the stimuli could fall into any of the 10 locations; in the second, they could fall into the middle eight columns,

in the third row, any of the middle six columns, and in the fourth row, any of the middle four locations. This arrangement was reversed for stimuli presented in the bottom display (see Figure 3, for example displays). Only display sizes 8 and 16 were used, to ensure that the total number of trials was similar to that of Experiment 1.

### *Design and procedure*

The experiment used a fully within-participants, 2 (target: present / absent) x 2 (distractor type: upwards or downwards pointing triangles) x 3 (display size: 8 or 16 items) x 2 (display location: top, bottom) design. Each combination of trial type was presented eight times to give a total of 128 trials per block (8 x 16). Each participant completed three blocks of 128 trials, resulting in 24 trials per cell, in a single session. Directly before the first full block of trials, participants were shown a short demonstration block and completed a practice block of 24 trials. Otherwise, the procedure was identical to that Experiment 1.

### **Results**

*Reaction times:* Mean correct RTs were calculated individually for each cell of the design and individually for each participant. Overall mean correct RTs and search slopes are shown in Figure 2. The data were analyzed using a 2 (target, present or absent) x 2 (distractor type, upward or downward pointing distractors) x 3 (display size, 8, 16, 24) x 2 (display location, top or bottom) within-participants ANOVA.

This revealed significant main effects of distractor type,  $F(1,23) = 7.49$ ,  $MSE = 4546.60$ ,  $p < .05$ , display size  $F(1,23) = 47.72$ ,  $MSE = 11899.53$ ,  $p < .001$ , and display location (floor-ceiling),  $F(1,23) = 37.16$ ,  $MSE = 7157.60$ ,  $p < .001$ . RTs were longer for displays with downwards pointing distractors, increased with display size, and were

shorter when the displays were at the top of the screen. There was also significant two-way interactions between target presence x distractor type,  $F(1,23) = 11.21$ ,  $MSE = 25759.22$ ,  $p < .005$ , and display location x display size,  $F(1,23) = 4.50$ ,  $MSE = 4195.51$ ,  $p < .05$ , and a distractor type x display location interaction,  $F(1,23) = 3.72$ ,  $MSE = 4792.49$ ,  $p = .066$ , which approached significance. The three-way target presence x distractor type x display size interaction was also significant,  $F(1,23) = 11.15$ ,  $MSE = 2920.72$ ,  $p < .005$ . No other main effect or their interaction approached significance, all  $F_s < 1.6$ , all  $p_s > .22$ . In order to clarify the higher order interactions, two additional ANOVAs were performed individually on the absent trial and the present trial data.

*Absent trials only:* RTs increased with display size,  $F(1,23) = 22.18$ ,  $MSE = 18109.30$ ,  $p < .001$ , and were shortest for displays with downward pointing distractors,  $F(1,23) = 5.31$ ,  $MSE = 11734.29$ ,  $p < .05$ , and also for displays presented at the top of the screen,  $F(1,23) = 28.82$ ,  $MSE = 6501.30$ ,  $p < .001$ . RTs also increased less with display size for displays presented at the top of the screen,  $F(1,23) = 5.91$ ,  $MSE = 2621.65$ ,  $p < .05$ . However, no other interactions were significant, all  $F_s < 1.5$ , all  $p_s > .24$ .

*Present trials only:* RTs increased with display size,  $F(1,23) = 26.44$ ,  $MSE = 7053.34$ ,  $p < .001$ , were shorter for downwards pointing targets than upward pointing target displays,  $F(1,23) = 14.03$ ,  $MSE = 18570.53$ ,  $p = .001$ , and also were shorter when the display was presented at the top of the screen,  $F(1,23) = 12.80$ ,  $MSE = 6867.70$ ,  $p < .005$ . There was also a significant distractor type x display size interaction,  $F(1,23) = 5.86$ ,  $MSE = 5305.29$ ,  $p < .05$ , indicating that search slopes were shallower for downward pointing targets (4.61 ms/item) than for upward pointing targets (11.0 ms/item). No other interactions approached significance, all  $F_s < 2.85$ , all  $p_s > .1$ .

*Errors:* Mean percentage error rates are shown in Table 2. There were more errors on present trials than on absent trials,  $F(1,23) = 34.45$ ,  $MSE = 61.24$ ,  $p < .001$ . Overall, errors were greater for displays in which the distractors were pointing downwards,  $F(1,23) = 10.10$ ,  $MSE = 36.26$ ,  $p < .005$ , and this effect was more pronounced on present trials than on absent trials,  $F(1,23) = 11.89$ ,  $MSE = 66.24$ ,  $p < .005$ . Errors also increased more with display size, when displays contained downward pointing distractors as shown by a significant stimulus type x display size interaction,  $F(1,23) = 8.62$ ,  $MSE = 38.77$ ,  $p < .01$ . In addition, a target presence x display size interaction,  $F(1,23) = 3.36$ ,  $MSE = 31.04$ ,  $p = .08$  approached significance. No other main effects or their interaction reached significance, all  $F_s < 2.4$ , all  $p_s > .136$ . As for the RT data, error rates were also analyzed separately for the absent and present trials.

*Absent trials only:* There were no significant main effects or their interaction, all  $F_s < 2.2$ ,  $p_s > .15$ .

*Present trials only:* Errors were greater for upward pointing targets than for downwards pointing targets,  $F(1,23) = 15.07$ ,  $MSE = 73.94$ ,  $p = .001$ , and this difference was greater at the larger display size,  $F(1,23) = 5.81$ ,  $MSE = 65.76$ ,  $p < .05$ ; errors tended to increase with display size for detecting an upwards pointing triangle but decrease for detecting a downwards pointing triangle target. No other main effect or their interaction approached significance, all  $F_s < 1.5$ ,  $p_s > .23$ .

Overall, in terms of triangle orientation, higher error rates were associated with longer RTs, suggesting that the important effects within the RT data were not compromised by any speed-accuracy tradeoff.

## **Discussion**

The main aim of Experiment 2 was to test an alternative account of the downwards pointing triangle advantage, based on whether or not the target matched or mismatched the perspective of the scene. This was achieved by placing the search displays in different contexts (floor or ceiling). If perspective effects played a role in the previous findings, then we should have reversed the target advantage when the displays were moved from floor to ceiling contexts. That is, when placed on the floor, an advantage for the downwards triangle should have emerged, because the target would be incongruent with the perspective. In contrast, when the search display was placed in the ceiling context, the upwards pointing triangle would now be incongruent with the display perspective, and so this scenario should show a search advantage.

The results were relatively clear, in that a search advantage remained for the downwards pointing target. This was based on overall RTs and search slopes, irrespective of whether the search display was presented within the floor or the ceiling perspective context. Accordingly, this rules out an account based on perspective-based differences between downward and upward pointing triangles, leaving the emotional context account as a plausible explanation (Larson et al., 2007; Tipples et al., 2002).

Interestingly, we also found an effect of stimulus type on absent trials but only in terms of overall RTs. Specifically, RTs for absent trials containing threat-related shapes were processed more quickly than those containing non-threat related distractors. This might be expected if negative stimuli initially attracted attention more rapidly than non-threat stimuli, which subsequently led to a more rapid initial onset of search. However, the direction of this difference and the lack of an effect on search slopes provide no

evidence that the threat stimuli were more difficult to disengage attention from, once the search had begun.

One unexpected finding was that overall RTs were shorter for displays presented within the ceiling context than those presented within the floor context. This is despite the fact that observers were asked to maintain their fixation on the fixation dot before the search display arrived. One possibility is that participants' saccadic latencies to the top display were shorter than to the bottom display, leading to a shorter overall response time. In support of this possibility, Heywood and Churcher (1980) found that saccadic latencies to a previously indicated targets were 31ms faster for upwards saccades than for downwards saccades (relative to the display center).

## **General Discussion**

Previous work has shown that threat-related or negative stimuli (particularly faces and face-related stimuli) appear to enjoy a selection advantage over non-threat or emotionally neutral stimuli. Such advantages are shown over a number of paradigms and tasks, including visual search (Eastwood et al., 2001; Blagrove & Watson, in press; Fox et al. 2000), flanker (Fenske & Eastwood, 2003; Horstman & Becker, 2008) and cueing tasks (Fox et al., 2001, 2002; Georgiou et al., 2005). Indeed, negative stimuli cannot only be found more rapidly, but may also capture our attention in an automatic fashion whilst we are engaged in other tasks (e.g., Eastwood, Smilek & Merikle, 2003). Clearly, determining what types of visual features generates such a search advantage is a valuable goal, if we are to discover the functional architecture of threat-related processing. In a recent study, Larson et al., (2007) examined whether minimal geometric shapes which

might be associated with the signaling of negative facial expression or threat (containing a downward pointing v-shape) could also guide/ attract attention efficiently, even when presented out of a face context. Over a series of several experiments, it was shown that when displays contained downwards pointing v-shapes amongst other simple shapes, they were detected faster overall than alternative orientations of the same shape (or other simple shape targets). In contrast, other work (Tipples, et al., 2002) found a search advantage for such shapes only when embedded within a face context.

The current study had several main aims. First, was to replicate the findings of Larson et al., in order to clarify previous inconsistent results in the literature. Second, was to eliminate some potential problems by presenting irregular, random displays of stimuli and by manipulating set size. This allowed us rule out possible differences between target detection, which might occur at the response stage, rather than being attributable to attentional guidance or capture differences. This also allowed us to measure whether any threat-based differences varied as a function of attentional competition. Finally, in Experiment 2, we tested an alternative account of the v-shape advantage, based on differences between the congruency of the target with its local perspective within the scene.

In both Experiments 1 and 2, we found that detecting a downwards pointing triangle (i.e. containing an upright v-shape) amongst upward pointing triangles was faster overall and produced a shallower search slope than the reverse task. This provides a valuable replication that indicates v-shaped stimuli enjoy a selection advantage, even when the stimulus is not embedded within a face context. Furthermore, the search advantage observed here cannot be attributed to response-based effects, because search



was more efficient based on search slope measures (in addition to overall RT measures). Neither can the advantage be due to responses based on texture discrimination, as in our experiments, the stimuli were presented randomly in the display rather than within a highly regular matrix. Thus, the data here provide a stronger test of the threat-related advantage hypothesis. Also of note is that the search slopes were highly linear, suggesting that the threat advantage remained relatively constant as attentional competition from other distractors increased. Similarly, there was no sign that the advantage decreased or became weaker as set size increased. Of course, one consequence of this is that the overall RT difference between the different target conditions also increased as set size increased, which again underlines the utility of varying set size in such studies.

Considering the general visual search literature, in Experiment 1, the overall search rates on target present trials ranged from what Wolfe (1998a; see also Wolfe 1998b) would be term “efficient” (less than approximately 5 ms/item) for the downwards pointing triangle target to “quite efficient” (approximately 5 to 10 ms/item) for the upwards pointing triangle target. Similarly, in Experiment 2, the downwards target was detected at a rate of less than 8 ms/item, with the upward target producing search slopes greater than 10 ms/item (see Wolfe, 1998b, for a consideration of the full range of search slopes across various types of visual search task).

In comparison, using schematic face stimuli, Öhman, Lundqvist and Esteves (2001; Experiment 2) found efficient (<5 ms/item) search slopes for negative and positive targets amongst neutral expression distractors. However, unlike the present work, although there was an overall RT advantage for negative over positive faces, there was no

search slope difference (although the error rate was greater for positive targets for the largest display matrix compared with the negative targets). This discrepancy might be due to differences in error rates across conditions and/or methodological differences. For example, Öhman, et al., used regular matrix displays (ranging from 2x2 to 5x5) which might have impacted on search efficiency (see earlier). In contrast, Blagrove and Watson (2010; Experiment 1) found much steeper search slopes of approximately 30 ms/item for the detection of a negative face target compared with approximately 45 ms/item for a positive target amongst neutral distractors. However, one difference between these two studies is that in the Öhman et al., study the stimuli contained eyebrows, where the stimuli used by Watson and Blagrove did not. Thus, when considered along with the current findings, this suggests that the presence of v-shapes might be particularly important in driving efficient visual search (although note also that Öhman et al., Experiment 3, also found relatively steep, approximately 35 ms/item, search slopes when the distractors were valenced rather than neutral).

The findings were also straightforward with respect to whether the v-shape advantage might be due to incongruence with the global scene perspective. According to this alternative account, the v-shaped advantage reported might have been due to the v-shape appearing to be incongruent in terms of perspective with the remaining distractors in the field. However, Experiment 2 appears to rule out this possibility; even when the perspective cues were reversed by placing the search display within a floor or ceiling context, a search advantage for the v-shaped target remained. In contrast, the data are consistent with a threat-based explanation as the threat-related status of the shape should not vary as a function of the local perspective / spatial context of the stimulus. These

findings mesh with a recent imaging study (Larson, Aronoff, Sarinopoulos & Zhu, 2008), which showed that downwards pointing triangles were more likely to activate brain areas associated with threat-related processing than upwards pointing triangles or outline circles. The data also support previous findings showing that people rate v-shapes more negatively than inverted v-shapes, even when presented in isolation and outside of a face context (Lundqvist, Esteves & Öhman, 2004; see also Larson et al., for the same finding with isolated triangle stimuli similar to those used in the present study).

Overall, our findings provide strong converging evidence that simple shapes, which might be especially important in providing emotional signals in faces, also attract attention preferentially when presented outside of a face context. However, our results provided little evidence that such stimuli also hold our attention, once captured. In both experiments, displays consisting of only negative stimuli (target absent trials) were not responded to more slowly overall, nor were search slopes steeper, than displays in which all the stimuli were positive. One possibility is that threat stimuli perhaps initially attracted attention more effectively, leading to a faster onset of search. Consequently, this might offset any subsequent disengagement-based slowing. However, although this might account for a lack of overall RT differences, it cannot account for a lack of slope differences. If threat-related stimuli held attention, then we would expect that each attentional movement would be slowed, and so this should lead to a steeper search slope (even if the initial onset of search was fast). Our data showed no such pattern. Importantly, Larson et al.'s results were somewhat inconclusive on this issue, finding evidence of slowing of attentional disengagement to negative stimuli in only a subset of their conditions. Clearly, determining the conditions under which attentional

disengagement will be delayed with isolated geometric stimuli, and its relation to disengagement effects found with more realistic face stimuli (e.g., Fox et al., 2001; Georgiou et al., 2005) will be a useful goal for future research. Indeed, if simple geometric shapes signal important attributes of expression in real faces, then we would expect to find commonalities between the situations in which both types of stimuli are successful in generating an attentional disengagement slowing.

### Footnotes

Effects sizes were calculated with Cohen's  $d$ , using the average standard deviation of the two samples (see Howell, 2007).

## References

- Blagrove, E., & Watson, D.G. (2010). Visual Marking and facial affect: Can an emotional face be ignored? *Emotion*, *10*, 147-168.
- Calvo, M.G., & Esteves, F. (2005). Detection of emotional faces: Low perceptual threshold and wide attentional span. *Visual Cognition*, *12*, 13-27.
- Davoli, C.C., Suszki, J.W., & Abrams, R.A. (2007). New objects can capture attention without a unique luminance transient. *Psychonomic Bulletin & Review*, *14*, 338-343.
- Doherty, L.M., Foster, D.H. (2001). Reference frame for rapid visual processing of line orientation. *Spatial Vision*, *14*, 121-137.
- Eastwood, J., Smilek, D., & Merikle, P.M. (2001). Differential attentional guidance by unattended faces expressing positive and negative emotion. *Perception & Psychophysics*, *63*, 1004-1013.
- Eastwood, J.D., Smilek, D., & Merikle, P.M. (2003). Negative facial expression captures attention and disrupts performance. *Perception & Psychophysics*, *65*, 352-358.
- Fenske, M.J., & Eastwood, J.D. (2003). Modulation of focused attention by faces expressing emotion: Evidence from flanker tasks. *Emotion*, *3*, 327-343.
- Fox, E., Lester, V., Russo, R., Bowles, R.J., Pichler, A., & Dutton, K. (2000). Facial expressions of emotion: Are angry faces detected more efficiently? *Cognition & Emotion*, *14*, 61-92.

- Fox, E., Russo, R., & Dutton, K. (2002). Attentional bias for threat: Evidence for delayed disengagement from emotional faces. *Cognition & Emotion, 16* (3), 335-379.
- Fox, E., Russo, R., Bowles, R.J., & Dutton, K. (2001). Do threatening stimuli draw or hold visual attention in subclinical anxiety. *Journal of Experimental Psychology: General, 130*, 681-700.
- Frischen, A., Eastwood, J.D., & Smilek, D. (2008). Visual search for faces with emotional expressions. *Psychological Bulletin, 134*, 662-676.
- Georgiou, G.A., Bleakley, C., Hayward, J., Russo, R., Dutton, K., Eltiti, S and Fox, E. (2005). Focusing on fear: Attentional disengagement from emotional faces. *Visual Cognition, 12*, 145-158.
- Gerritsen, C., Frischen, A., Blake, A., Smilek, D., & Eastwood, J. D. (2008). Visual search is not blind to emotion, *Perception & Psychophysics, 70*, 1047-1059.
- Horstmann, G., & Becker, S. I. (2008). Attentional effects of negative faces: Top-down contingent or involuntary? *Perception & Psychophysics, 70*, 1416-1434.
- Howell, D.C. (2007). *Statistics methods for psychology*. Belmont, CA: Thomson Wadsworth.
- Johnson, M.H. (2005). Subcortical face processing. *Nature Reviews Neuroscience, 6*, 266-274.
- Juth, P., & Lundqvist, D., Karlsson, A., & Öhman, A. (2005). Looking for foes and friends: Perceptual and emotional factors when finding a face in the crowd. *Emotion, 5*, 379-395.

- Kanwisher, N., McDermott, J., & Chun, M.M. (1997). The fusiform face area: A module in human extrastriate cortex specialized for face perception. *Journal of Neuroscience*, *17*(11), 4302–4311.
- Lappin, J.S., Shelton, A.L. & Rieser, J.J. (2006). Environmental context influences visually perceived distance. *Perception & Psychophysics*, *68*, 571-581.
- Larson, C.L., Aronoff, J., Sarinopoulos, I.C., & Zhu, D.C. (2008). Recognizing threat: A simple geometric shape activates neural circuitry for threat detection. *Journal of Cognitive Neuroscience*, *21*, 1523-1535.
- Larson, C.L., Aronoff, J., & Stearns, J.J. (2007). The shape of threat: Simple geometric forms evoke rapid and sustained capture of attention. *Emotion*, *7*, 526-534.
- LeDoux, J. E. (1998). Fear and the brain: Where we have been, and where are we going? *Biological Psychiatry* *44*, 1229-1238.
- LeDoux, J.E. (1996) *The emotional brain*. New York: Simon & Schuster.
- Lundqvist, D., Esteves, F., & Öhman, A. (2004). The face of wrath: The role of features and configurations in conveying social threat. *Cognition & Emotion*, *18*, 161 - 182
- Marendaz, C. (1998). Nature and dynamics of reference frames in visual search for orientation: Implications for early visual processing. *Psychological Science*, *9*, 27-32.
- Öhman, A., & Mineka, S. (2001) Fears, phobias and preparedness: Towards an evolved module of fear and fear learning. *Psychological Review*, *108*, 483-522.
- Öhman, A., Lundqvist, D., & Esteves, F. (2001). The face in the crowd revisited: A threat advantage with schematic stimuli. *Journal of Personality & Social Psychology*, *80*, 381–396.



- Palermo, R., & Rhodes, G. (2007). Are you always on my mind? A review of how face perception and attention interact. *Neuropsychologia*, *45*, 75-92.
- Sagiv, N., & Bentin, S. (2001). Structural encoding of human and schematic faces: Holistic and part-based processes. *Journal of Cognitive Neuroscience*, *13*, 937-951.
- Schubö, A., Gendolla, G.H.E., Meinecke, C. & Abele, A.E. (2006). Detecting emotional faces and features in a visual search paradigm: Are faces special? *Emotion*, *6*, 246-256.
- Tipples, J., Atkinson, A. P., Young, A. W. (2002). The eyebrow brown: A salient social signal. *Emotion*, *2*, 288-296.
- Treisman, A. (1985). Preattentive processing in vision. *Computer vision, Graphics, and Image processing*, *31*, 156-177.
- Treisman, A., & Gormican, S. (1988). Feature analysis in early vision: Evidence from search asymmetries. *Psychological Review*, *95*, 15-48.
- Treisman, A., & Souther, J. (1985). Search asymmetry: A diagnostic for preattentive processing of separable features. *Journal of Experimental Psychology: General*, *114*, 285-319.
- Vuilleumier, P., Armony, J. L., Driver, J., & Dolan, R.J. (2001). Effects of attention and emotion on face processing in the human brain: an event-related fMRI study. *Neuron*, *30*, 829-841.
- Watson, D.G. & Humphreys, G.W. (1997). Visual Marking: Prioritizing selection for new objects by top-down attentional inhibition of old objects. *Psychological Review*, *104*, 90-122.

- Watson, D.G., & Humphreys, G.W. (1998). Visual marking of moving objects: A role for top-down feature-based inhibition in selection. *Journal of Experimental Psychology: Human Perception and Performance*, *24*, 946-962.
- White, M. (1995) Preattentive analysis of facial expressions of emotion. *Cognition & Emotion*, *9*, 439-460.
- Williams, M.A., Moss, S.A., Bradshaw, J. L., Mattingley, J.B. (2005). Look at me, I'm smiling: Visual search for threatening and non-threatening facial expressions. *Visual Cognition*, *12*, 29-50.
- Wolfe, J. M. (1998a). Visual search. In H. Pashler (Ed.), *Attention* (pp. 13-74). Hove, East Sussex, England: Psychology Press.
- Wolfe, J.M. (1998b). What can 1 million trials tell us about visual search? *Psychological Science*, *9*, 33-38.
- Wolfe, J.M. (1992). "Effortless" texture segmentation and "parallel" visual search are not the same thing. *Vision Research*, *32*, 757-763.
- Wolfe, J.M. (2001). Asymmetries in visual search: An introduction. *Perception & Psychophysics*, *63*, 381-389.
- Wright, C.I., Martis, B., Shin, L.M., Fischer, H., & Rauch, S.L. (2002). Enhanced amygdala responses to emotional versus neutral schematic facial expressions. *NeuroReport*, *13*, 785-789.
- Yantis, S. & Jonides, J. (1984). Abrupt visual onsets and selective attention: Evidence from visual search. *Journal of Experimental Psychology: Human perception and performance*, *10*, 601-621.

Yantis, S., & Hillstrom, A.P. (1994). Stimulus-driven attentional capture: Evidence from equiluminant visual objects. *Journal of Experimental Psychology: Human Perception and Performance*, 20, 95-107.

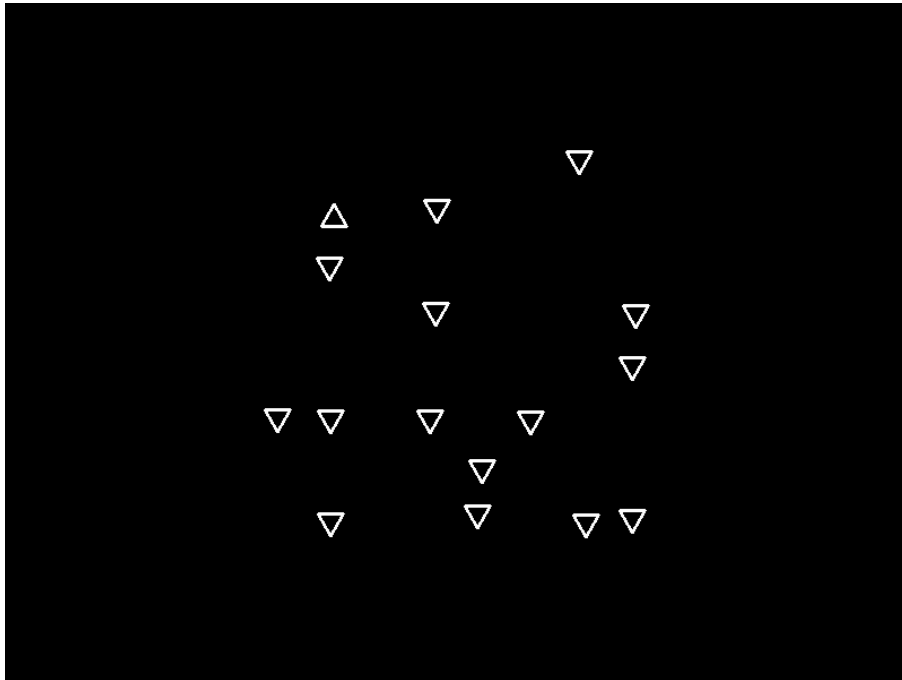
Table 1. Mean percentage error rates as a function of target presence, stimulus type and display size for Experiment 1. D-Down = downwards pointing distractors, D-Up = upwards pointing distractors, T-Down = downwards pointing target, T-Up = upwards pointing target.

	Display size		
	8	16	24
Absent, D-Down	3.33	2.08	2.50
Absent, D-Up	3.75	4.31	2.50
Present, D-Up, T-Down	4.86	6.11	5.83
Present, D-Down, T-Up	9.86	12.22	17.36

Table 2. Mean percentage error rates as a function of target presence, stimulus type, display size and display location for Experiment 2. D-Down = downwards pointing distractors, D-Up = upwards pointing distractors, T-Down = downwards pointing target, T-Up = upwards pointing target.

	Display Size	
	8	16
	Ceiling	
Absent, D-Down	3.65	3.13
Absent, D-Up	4.69	3.47
Present, D-Down, T-Up	9.20	14.06
Present, D-Up, T-Down	7.81	6.42
	Floor	
Absent, D-Down	3.65	4.34
Absent, D-Up	6.25	3.99
Present, D-Down, T-Up	9.20	12.50
Present, D-Up, T-Down	6.60	4.86

A)



B)

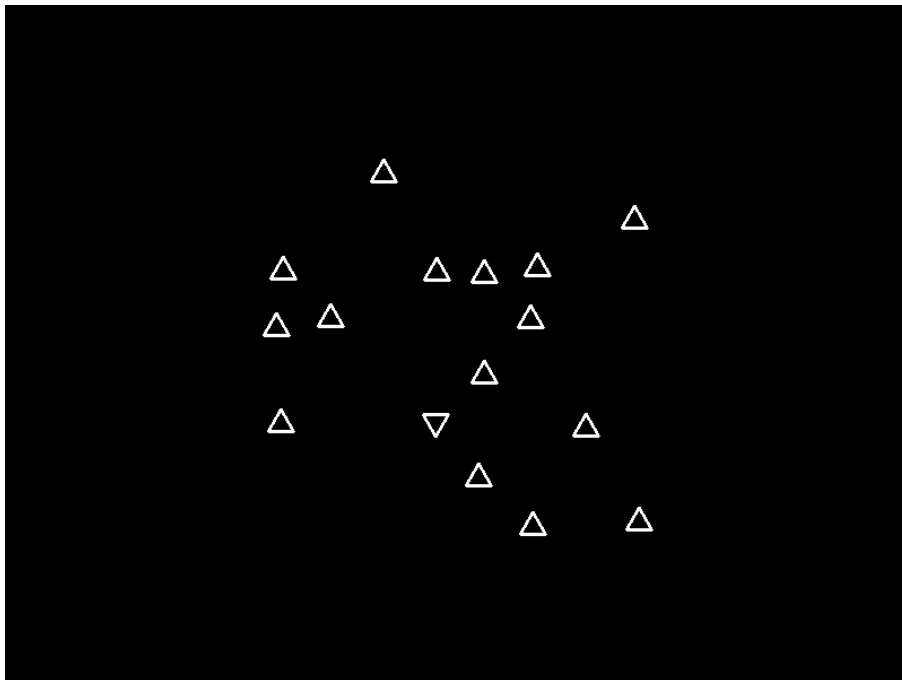


Figure 1. Example displays (to scale) from Experiment 1 for display size 16, target present trials. Panel A shows an upwards pointing target display and panel B a downwards pointing target display.

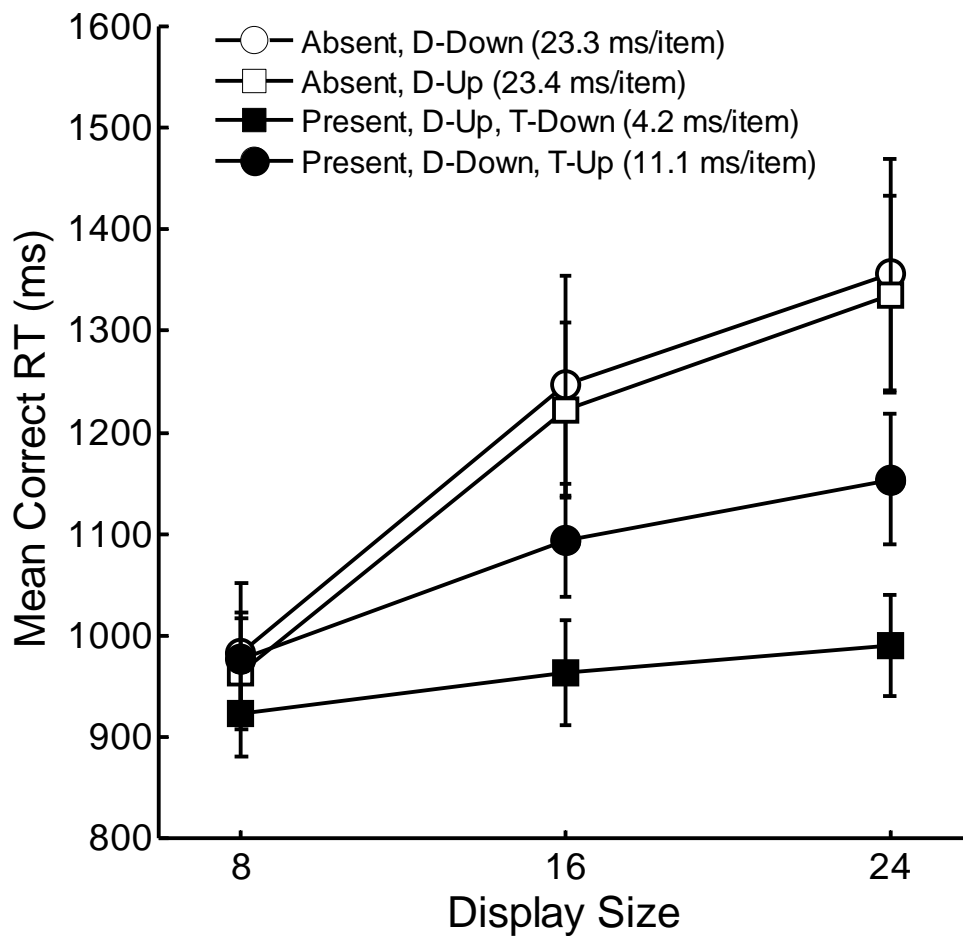


Figure 2. Mean correct RTs (search slopes in brackets) as a function of target presence, stimulus type and display size for Experiment 1. D-Down = downwards pointing distractors, D-Up = upwards pointing distractors, T-Down = downwards pointing target, T-Up = upwards pointing target. Error bars indicate  $\pm 1$  standard error of the mean.

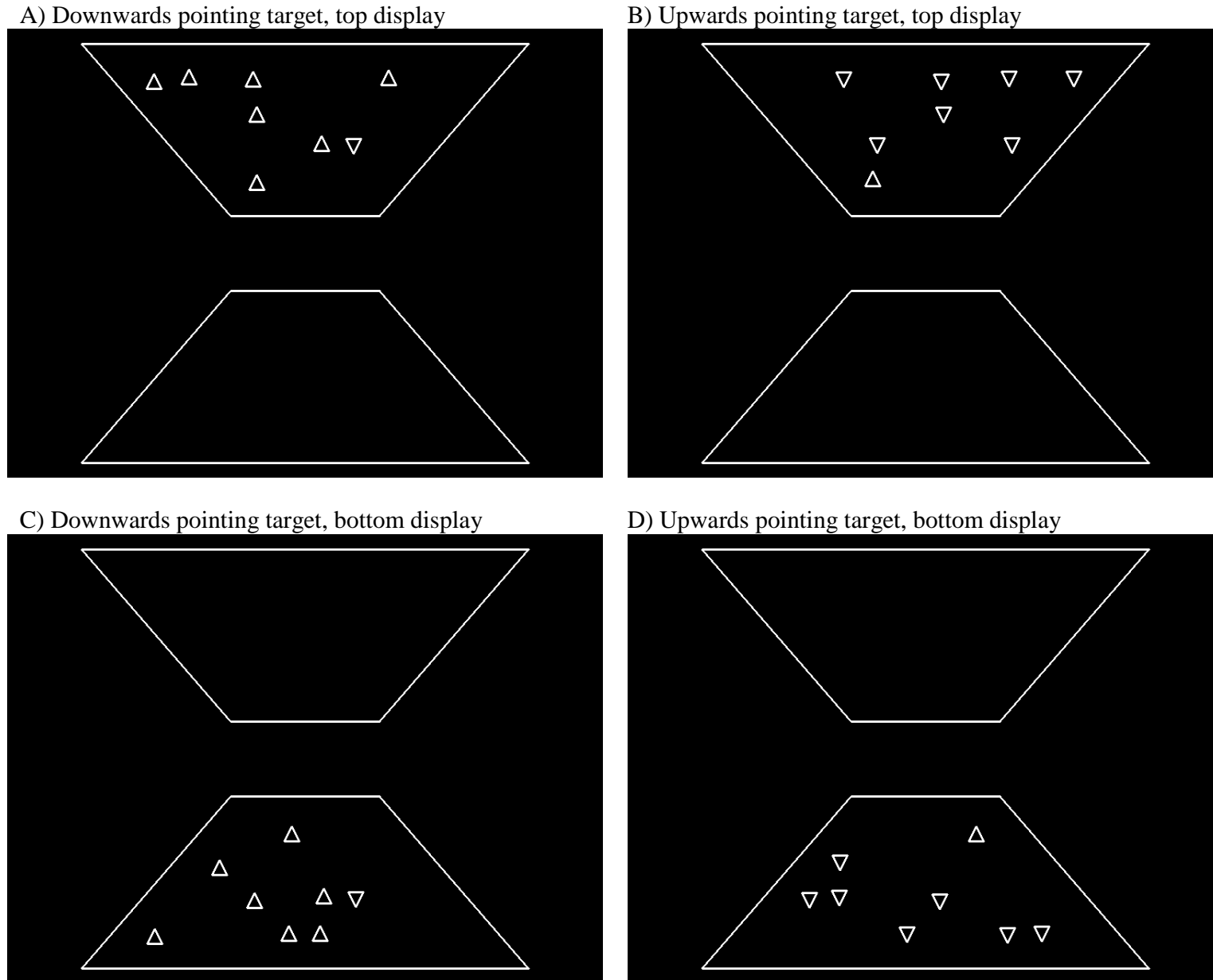


Figure 3. Example stimuli for display size 8 of Experiment 2 as a function of target orientation and search display position. In panels A and D the target is congruent with perspective and the distractors are incongruent, in panels B and C the reverse is true.



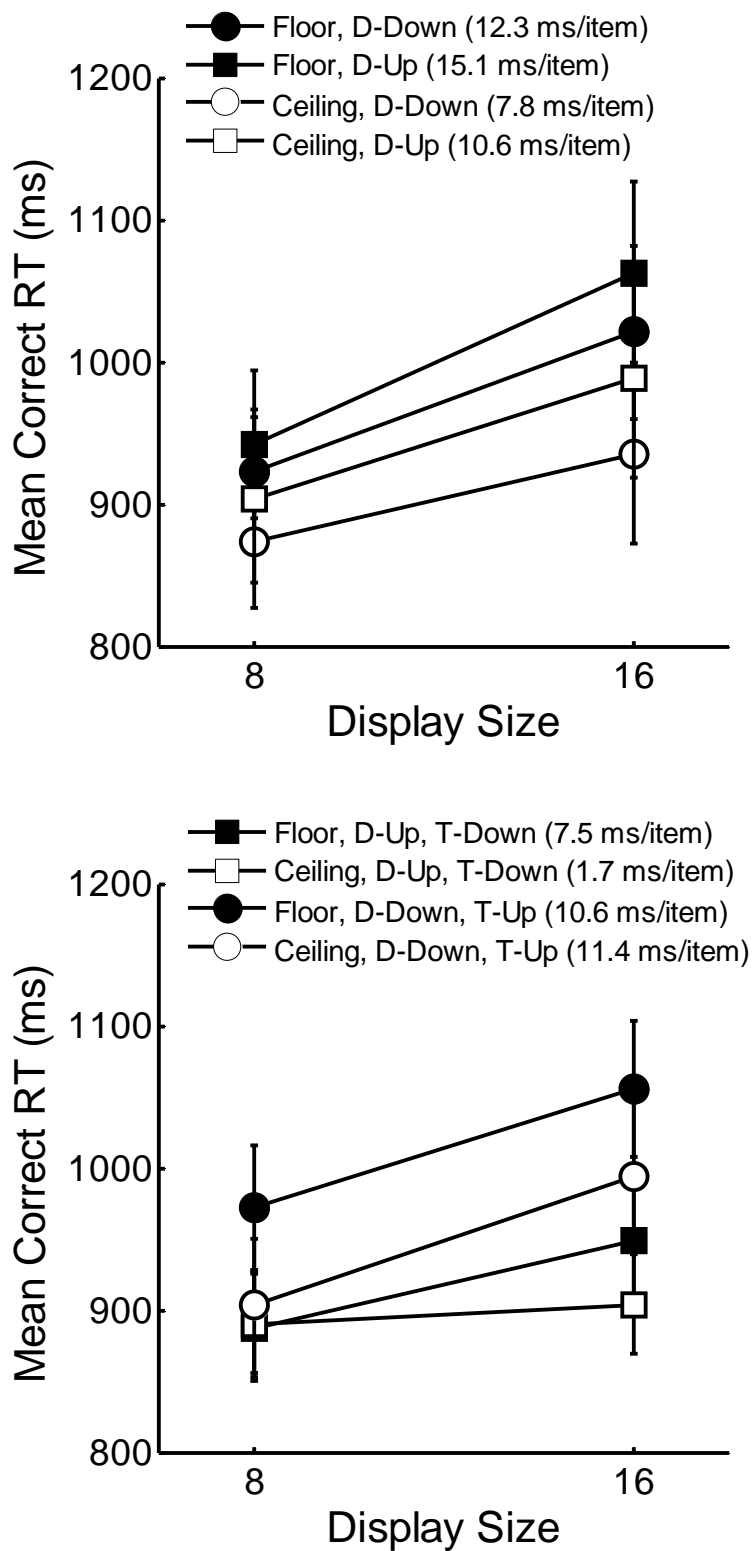


Figure 4. Mean correct RTs and search slopes for Experiment 2 for target absent trials (top) and target present trials (bottom).