Visual search for schematic emotional faces: angry faces are more than crosses

Daina S.E. Dickins & Ottmar V. Lipp

School of Psychology, The University of Queensland, QLD, 4072, Australia

Running head:

Search for schematic emotional faces

Address for correspondence:

Daina S.E. Dickins, School of Psychology, The University of Queensland, QLD, 4072, Australia.

E-mail: daina.dickins@uqconnect.edu.au

Ottmar V. Lipp, PhD, School of Psychology, The University of Queensland, QLD, 4072, Australia. E-mail: o.lipp@uq.edu.au

Acknowledgments:

This work was supported by Grant DP110100460 from the Australian Research Council. We are grateful to Dr Coelho for permission to use his stimuli and to Ms Jenna Scambler and Ms Mylyn Dat for assistance with datacollection.

Abstract

Recent studies of the face in the crowd effect, the faster detection of angry than of happy faces in visual search, suggest that for schematic faces it reflects on perceptual features like inward pointing lines rather than on emotional expressions. Removing a potential confound, Experiments 1-2 replicate the preferential detection of stimuli with inward pointing lines, but Experiment 2a indicates that a surrounding circle is required for the effect to emerge. Experiments 3-7 failed to find evidence for faster detection of schematic faces comprising only the elements critical for the faster detection of angry faces according to a low level visual feature account, inward tilted brows and upturned mouth. Faster detection of anger was evident if eyes or eyes and noses were added, but only if their placement was consistent with the first order relations among these elements in a human face. Drawing the critical elements in thicker, higher contrast lines also led to an anger advantage, but this was smaller than that seen for the complete faces. The present results suggest that, while able to support faster target detection, a prevalence of inward pointing lines is not sufficient to explain the detection advantage of angry schematic faces.

Key words: Face in the crowd effect, anger superiority effect, visual search, schematic faces.

The face in the crowd effect, the faster detection of angry than of happy faces in crowds of neutral or emotional faces is one of the best known phenomena in human face perception since it was first described by Hansen and Hansen (1988). It has also been one of the more controversial ones. Purcell, Stewart, and Skov (1996) were among the first to point to problems with the original research indicating that rather than mediated by emotion, faster detection of angry faces was reflective of a stimulus artefact that had been introduced during the editing of the stimulus materials. Once the artefact was removed, faster detection of happy faces seemed to emerge instead of faster detection of angry faces. The question as to which emotion is detected preferentially endures as has the question as to whether preferential detection reflects on the processing of emotion at all or is driven by low level perceptual features. The former issue is well illustrated by two major reviews of the literature Frischen, Eastwood, and Smilek (2008) and Becker, Anderson, Mortensen, Neufeld, and Neel (2011) which came to opposing conclusions. Frischen et al. concluded that angry faces are found preferentially whereas Becker et al. concluded that happy faces are found preferentially (for a more detailed discussion see Savage, Lipp, Craig, Becker, & Horstmann, 2013).

Purcell et al's (1996) finding that low level perceptual features can confound research on the face in the crowd effect led other researchers to advocate the use of schematic faces as a proxy for the more variable photographic faces used by Hansen and Hansen (Nothdurft, 1993; Öhman, Lundqvist & Esteves, 2001; Calvo, Avero, & Lundqvist, 2006; Horstmann, 2009). The use of schematic faces traded external validity for enhanced control over the stimulus materials, in that these are identical with the exception of the stimulus elements thought to be critical for the formation of an expression – eyebrows and mouth. However, this enhanced control has been achieved only to a limited extent as indicated in a study by Horstmann (2007) who found considerable differences in search efficiency across different sets of schematic faces which had been used in previous research. More recently, the use of schematic faces has been criticised as introducing another low level perceptual confound rather than resolving their influence. Using schematic faces similar to those used by Öhman et al. (2001), Purcell and Stewart (2010) found similar patterns of search performance with emotional schematic faces and schematic faces that comprised the same elements, but rearranged in a manner that reduced the impression of an emotional expression. Purcell and Stewart (2010) concluded that preferential detection of angry faces reflected on the interaction between some of the internal features of the faces, mouths and eyebrows, and the face circumference. This interaction resulted in either conforming, the shape of eyebrows and mouth in the happy face follow the contour of the face circumference, or non-conforming, the shape of eyebrows and mouth in the angry face oppose the contour of the face circumference, features which can mediate differential detection in absence of differences in perceived emotional expressions.

Coelho, Cloete, and Wallis (2010) presented a similar argument suggesting that the preferential detection of angry schematic faces among happy backgrounds reflects on the preponderance of inward pointing lines in the angry face relative to the radial lines that dominate in the happy faces. Coelho et al. asked participants to perform four search tasks. In two of the tasks, participants searched for angry faces among happy faces and for happy faces among angry faces, revealing the usual anger superiority effect – faster detection of angry targets. However, the same pattern of results emerged when participants were asked to search for stimuli comprising only the circumference and inward pointing or radial lines (see Figure 1, row 1, angry and happy) and for the same stimuli rotated by 45° which was done to render them less face like (see Figure 1, rows 2 and 3, angry and happy). The inward pointing or radial lines are said to represent the most salient and distinctive features of the angry and happy schematic faces, eyebrows and mouths. Thus, it is concluded that preferential detection of angry schematic faces in visual search does not reflect on the emotion expressed, but on differences in the preponderance of lower-level perceptual features.

Insert Figure 1 about here

There are, however, several problems with this conclusion. First, Coelho et al. (2010) employed a fixed target search which confounded the nature of target and background stimuli; participants searched for angry targets among happy backgrounds in one block and for happy targets among angry backgrounds in a second. Performance on non-target trials suggested that for both, face and line stimuli search through happy backgrounds was faster than search through angry backgrounds (see also Horstmann, Scharlau, & Ansorge, 2006). Thus, faster detection of angry targets may reflect on faster search through happy backgrounds. This confound can be avoided if participants are asked to search for emotional targets among neutral backgrounds, either within the same block or across blocks (Lipp, Price & Tellegen, 2009a, b). Experiments 1 and 2 were designed to address this issue. Second, the assumption that inward pointing or radial lines are an adequate representation of the distinctive features of angry or happy schematic faces, eyebrows and mouths, was not tested explicitly (see Figure 1, rows 1 vs. 5). If this were the case then search for schematic faces from which eyes and nose stimuli were removed and which are reduced to eyebrows and mouth lines should, like search with complete faces, yield faster detection of angry expressions. This issue is addressed in Experiments 3-8.

Experiment 1

The purpose of Experiment 1 was to replicate Coelho et al. (2010) eliminating the potential background confound. Scheming and sad expressions (see row 1, Figure 1) were included to enhance compatibility with previous research that employed schematic faces (Öhman et al., 2001; Lipp et al., 2009a, b). Moreover, a variable target search task was employed in which participants were asked to search for stimuli that were different among a constant set of background stimuli. If the faster detection of ‘angry’ targets reported by Coelho et al. (2010) was solely due to slower search through ‘happy’ backgrounds, then removing this confound should eliminate any difference in the speed of target detection. Therefore, an emotion based account would predict that detection time should not differ across targets, when presented amongst neutral distractors, whereas the perceptual account predicts that a difference should emerge.

Method

Participants

Eighteen undergraduate psychology students, aged between 17 and 34 years (15 female; *M* = 20.11 years) provided informed consent and volunteered participation in exchange for course credit. Participants were tested individually and completed four RT tasks, the first of which is reported here. All experimental procedures were approved by the University of Queensland’s Ethics Review Board.

Materials

The experiment was run using a 17-inch (1280 x 1024 pixels; 75 Hz refresh rate) CRT monitor attached to a 486 compatible PC. DMDX software (Forster & Forster, 2003) controlled stimulus presentation and response time recording. Participants were presented with nine picture matrices organized in a 3 x 3 grid. Each matrix consisted of either nine neutral configurations (non-target trial) or eight neutral configurations and one target (target trial). The target was either a happy, angry, sad or scheming configuration (see row 1 of Figure 1). Each picture was 150 x 150 pixels in size and 3.5 cm in circumference. The nine pictures were presented in a 3 x 3 grid, 750 x 750 pixels in size which was segmented into nine segments sized 250 x 250 pixels. The position of the top left corner of each individual picture varied randomly in steps of 50 pixels from 0 to 100, vertically and horizontally to jitter its position within the grid. A two-button button box (button diameter = 1 cm, placed 10 cm apart, centre to centre, labelled ‘same’ or ‘different’) was used to record responses. Label position was counterbalanced across participants.

The ‘angry’ and ‘happy’ stimuli used in Experiment 1 were identical to those used by Coelho et al. (2010; we thank Dr Coelho for access to the stimuli), consisting of black lines, positioned concentrically or radially within an outer circumference, upon a white background. These lines are thought to mimic the position of the eyebrows and mouth in happy and angry schematic faces. We created three additional expressions, scheming, sad, and neutral (see Table 1), by rearranging the positions of the lines within the circumference. Scheming and sad expressions were formed by inverting the lines corresponding to the mouth in angry and happy configurations. The neutral configuration was created through horizontally aligning each of the four lines within the circumference.

<u>Procedure</u>

Participants were seated 70 cm from the monitor and informed as to the general procedure before completing a block of ten practice trials, after which any questions were addressed. Then the experimental task commenced and participants were asked to respond as quickly and as accurately as possible. The task comprised 216 trials split into 4 blocks of 72, 36 Target and 36 No target trials, presented without interruption. Within each block, each target face appeared once in each of the nine possible positions. A trial consistent of a black fixation cross presented centred for 500ms (‘+’ sign in Arial 12 font), the picture matrix, presented for 5 s or until the participants' response and a blank screen presented for 1 s. Trials were presented in four different pseudo-randomised sequences such that no more than three Target or No-Target trials occurred consecutively, and that the serial position of the four targets was counterbalanced across participants.

Data Preparation and Statistical Analysis

Prior to analysis, response times less than 100ms or three standard deviations above and below the participants' mean were removed and coded as errors. Response times for each Target were averaged across target positions and trial blocks. Response times and average error percentages were subjected to within subject one-way analyses of variance (ANOVA). For this and all subsequent analyses Greenhouse- Geisser corrected values are reported for all main effects and interactions involving the repeated measures factor Emotion. Follow up analyses were conducted with t-tests and the critical values for these t-tests were derived from Sidak's tables to protect against the accumulation of α-error (Rohlf & Sokal, 1995). The level of significance was set at .05 for all statistical analyses.

Results and Discussion

As displayed in the left panel of Figure 2, participants were faster to detect 'angry' targets than 'happy' targets $t(15) = 3.54, p < .01$, with 'scheming' and 'sad' targets not differing from either, $F(3, 51) = 5.31$, $p = .005$, $p\eta^2 = .238$, $\acute{\varepsilon} = .834$. This finding does not reflect on a speed accuracy trade-off as the analysis of the errors yielded a similar pattern of results, $F(3, 51) = 3.89$, $p = .028$, $p\eta^2 = .186$, $\acute{\varepsilon} = .690$, with fewer errors for angry than for happy targets, $t(51) = 2.65$, $p < .05$, Angry: M = 2.88%, SD = 4.32, Scheming: M = 4.94%, SD = 5.08, sad: M = 6.58%, SD = 8.94, happy: M = 7.61%, SD = 6.66.

Insert Figure 2 about here

The results of Experiment 1 confirm the results reported by Coelho et al. (2010) in that inward pointing lines were found faster than radially oriented ones. In their report, Coelho et al. reported a second experiment in which they employed the same images rotated by 45° as the upright symbols may have resembled faces. Experiment 2 was conducted to replicate this finding employing left or rightward tilted stimuli for half the participants (see Figure 1, rows 2 and 3).

Experiment 2

Method

Nineteen undergraduate psychology students, aged between 17 and 48 years (14 female; *M* = 22.75 years) participated in exchange for course credit. Informed consent was provided by each participant. The experimental procedure was identical to Experiment 1 with the exception that tilted stimuli replaced the stimuli used in Experiment 1 (See Figure 1 rows 2 and 3). Data processing and analyses were the same as in Experiment 1.

Results and Discussion

As shown in the middle panel of Figure 2, participants were faster to find the ‘angry’ configuration than the ‘scheming’ and ‘sad’ ones and faster to find the ‘scheming’ and ‘sad’ ones than the ‘happy’ ones, all $t(54) > 2.59$, $p < .05$, $F(3, 54) = 31.11$, $p < .001$, $\eta^2 = .633$, $\acute{\varepsilon} = .752$. The analysis of the error percentages yielded no significant result with overall errors below 5%. Experiment 2a followed up on these findings and assessed whether angry faces are indeed just crosses as suggested by Coelho et al. (2010) or whether a more face like stimulus is required to find a detection difference across stimulus configurations. To achieve this, we replicated the procedure of Experiment 1, but removed the circle that had surrounded the crosses.

Experiment 2a

Method, Results, and Discussion

Twenty-nine undergraduate psychology students, aged between 17 and 23 years (19 female; *M* = 19.52 years) participated in exchange for course credit and provided informed consent. The experimental procedure was identical to Experiment 1 with the exception that the circles surrounding the crosses were removed (See Figure 1 row 4) and that participants were tested in groups of up to six. Data processing and analyses were the same as in Experiment 1.

As shown in the right panel of Figure 2, there were no differences in detection time across the four stimulus configurations, $F(3,84) = 1.152$, $p = .329$, $\eta_p^2 = .040$, $\acute{\varepsilon} = .806$. The analysis of the error percentages yielded no significant result with overall errors below 5%. Experiment 2 confirms the findings of Experiment 1 and of Coelho et al. (2010) that configurations with inward pointing lines are detected faster than radial ones. It clearly rejects the notion that the results reported by Coelho et al. reflect merely on an effect of the different background stimuli used across the two fixed target search tasks. Experiment 2a suggests that the circle surrounding the crosses is necessary for the faster detection of inward pointing lines relative to radial ones. This may suggest that the differential detection observed in Experiment 1 is reflective of the interaction between internal lines and circumference as suggested by Purcell and Stewart (2010). It should be noted, however, that removal of the circumference sped performance by more than 100 ms which may have resulted in a floor effect.

Experiment 3

The results of Experiments 1 and 2 suggest that previous reports of faster detection of angry schematic faces do not reflect on the emotion expressed by these faces. Rather they reflect on the preponderance of inward pointing lines in these stimuli which are found faster than are the radial lines which predominate in happy schematic faces. The schematic emotional faces, which have been used in previous research by us and others, consist of two sets of stimulus elements – those that distinguish the emotional expressions, eyebrows and mouth, and those that are constant across them, circumference, eyes, and nose (for illustration see Figure 1, rows 5 and 6). If the faster detection of angry schematic faces indeed reflects on the preponderance of inward pointing lines, as suggested by Experiments 1 and 2, then it should also emerge for 'face' stimuli that comprise only the circumference, the mouth and the eyebrows, but from which the redundant elements, eyes and nose, have been removed (see Figure 1, row 6). These stimuli retain the inward pointing or radial stimulus elements that determine differences in target detection according to a perceptual account. They do not have stimulus aspects that, arguably, render the schematic stimuli more face like and hence should aid the detection of emotional expressions.

Method

Twenty-four participants naïve to the tasks (11 male; mean age 20.8 years; range 17-28 years) volunteered participation. Each participant completed two tasks in counterbalanced order, one involving the schematic face stimuli displayed in row 5 of Figure 1, and one involving the feature stimuli in row 6. The general procedure was the same as in Experiment 1, however, the experiment was controlled by a DOS based, custom written software and the position of the pictures in the 3 x 3 grid was fixed. Data reduction and analysis were as in Experiment 1. Preliminary analyses revealed that task sequence did not affect the results and analyses were collapsed across this factor.

Results and Discussion

As shown in Figure 3, participants were faster to detect targets in the feature than in the face task, and effects of emotional expression were clearly evident in the face, but not in the feature task. These impressions were confirmed in the 2 x 4 (Task [Features vs. Face] x Emotion [Angry, Scheming, Sad, Happy]) factorial ANOVA which yielded main effects for Task, $F(1, 23) = 36.92$, $p < .001$, $\eta^2 = .616$, and Emotion, $F(3, 69) = 20.62$, $p < .001$, $\eta^2 = .473$, $\acute{\varepsilon} = .864$, as well as a Task x Emotion interaction, $F(3, 69) = 6.94$, $p = .001$, $\eta^2 = .232$, $\acute{\varepsilon} = .760$. Post hoc comparisons confirmed that participants were faster to find angry and scheming faces than sad and happy faces, all $t(69) > 3.40$, $p < .01$, whereas there was no difference among the features, largest $t(69) < 2.0$, angry vs. happy $t(69) = 1.27$, ns. The analysis of the error percentages yielded a main effect of Emotion, $F(3, 69) = 4.32$, $p = .013$, $\eta^2 = .158$, $\acute{\varepsilon} = .792$, but the interaction was not significant, $F(3, 69) = 2.52$, $p = .074$, $\eta^2 = .099$, $\acute{\varepsilon} = .873$. Participants made more errors when detecting happy than angry targets, M = 7.18%, SD = 6.57 vs. M = 4.63%, SD = 6.51, $t(69) = 2.69$. Performance with scheming, M = 5.40%, SD = 6.08, and sad targets, M = 6.71%, SD = 7.56, did not differ from either.

Insert Figure 3 about here

The results of Experiment 3 suggest that previous reports of faster detection of angry than of happy schematic faces cannot be explained as a function of the preponderance of inward pointing vs. radially oriented lines in angry faces. When participants were presented with reduced ‘face’ stimuli which comprised only the critical features circumference, mouth, and eyebrows, the features that the line stimuli used by Coelho et al. were designed to mimic, no difference in the speed of detection was observed. This may suggest that the process that drove the faster detection of ‘angry’ targets in Experiments 1 and 2 is not (solely) responsible for the faster detection of angry schematic faces in Experiment 3.

It is interesting to note that the overall performance was slower in the face than in the feature task. This is surprising in that the only difference between feature and face stimuli was a set of constant elements – eyes and nose – whereas the critical elements of the stimuli that differentiated backgrounds and targets did not change. One may argue that the addition of the redundant elements led to crowding (Whitney & Levi, 2011) which can slow performance, an interpretation that is consistent with the observation that performance on the No target trials was also slower in the face than in the feature condition, Mean = 1053 ms, SD = 283 vs. M = 739 ms, SD = 229, $t(23) = 7.81$, $p < .001$. However, it is not clear why crowding should have differential effects on different stimulus configurations, .i.e., slow performance by 75 ms for angry face targets and by 150 ms for happy ones. Experiment 4 was designed to follow up on this finding by employing feature stimuli with eyes only or with eyes and noses. It was designed to assess how much additional stimulus material is required in order to observe the differential detection across emotional expressions.

Experiment 4

Method

Twenty-four undergraduate psychology students aged between 17 and 24 years (14 male, 10 female; *M* = 19.21 years) volunteered participation. Each participant completed the two tasks reported here in counterbalanced order, as well as two unrelated tasks. Experiment 4 was run using the same apparatus and procedure as Experiment 1. Participants completed two search tasks comprising the stimuli depicted in rows 7 and 8 of Figure 1. Data processing and analyses were the same as in Experiment 1.

Results and Discussion

As shown in Figure 4, participants were faster to detect targets in the eyes only task than in the face task, however, effects of emotional expression were clearly evident in both. This pattern is confirmed in the 2 x 4 (Task [Eyes only vs. Face] x Emotion [Angry, Scheming, Sad, Happy]) factorial ANOVA which yielded main effects for Task, $F(1, 23) = 15.09$, $p = .001$, $\eta^2 = .396$, and Emotion, $F(3, 69) = 18.40$, $p < .001$, $\eta^2 = .444$, έ = .753, but no Task x Emotion interaction, $F(3, 69) = 1,75$, $p = .180$, $\eta^2 = .071$, έ = .753. Post hoc comparisons confirmed that participants were faster to find angry, scheming, and sad faces than happy faces, all $t(69) > 2.74$, $p < .05$, and faster to find angry than sad faces, $t(69) = 2.61$, $p < .05$. The analysis of errors yielded a main effect for Emotion, $F(3, 69) = 16.73$, $p < .001$, $\eta^2 = .421$, έ = .655. Participants made more errors when searching for happy faces, M=12.89%, SD = 13.18, than for angry, M=6.79%, SD = 13.47, scheming, M=5.79%, SD = 10.83, or sad faces, M=8.57%, SD = 12.58.

Insert Figure 4 about here

Experiment 4 confirmed that the addition of eyes was sufficient to alter the pattern of results seen in Experiment 3 with the features only. Participants were faster to search face stimuli without noses than those with noses, but displayed a search advantage for the angry face relative to the happy one. Moreover, this pattern of results did not differ between tasks. Thus, the addition of eyes was sufficient to yield an emotion effect which had been absent without them.

Experiment 5

Experiment 5 was designed to follow up on the finding that adding eyes to the feature stimuli yielded differences in target detection that are consistent with an emotion effect and which had not been evident with the feature stimuli alone. Given that the eyebrows may be perceived as eyes if lowered relative to the circumference (see Figure 1, row 10), Experiment 5 was designed to assess whether a difference in target detection across stimulus configurations is observed if the feature stimuli are altered like this.

Method

The participants were the same as those for Experiment 1. They completed two tasks which employed the stimuli shown in Figure 1, rows 9 and 10, faces and feature stimuli with lowered eyebrows. One participant did not complete the second task leaving 17 complete data sets. Method and procedure were the same as in Experiment 1 with the exception that the positions of the stimuli in the 3 x 3 search grid were fixed.

Results and Discussion

Figure 5 summarises the results of Experiment 5. As can be seen, and consistent with the results of Experiment 3, target detection times differed across stimuli in the face condition, but not in the feature condition. The 2 x 4 (Task [Features vs. Face] x Emotion [Angry, Scheming, Sad, Happy]) factorial ANOVA yielded main effects for Task, $F(1, 16) = 37.64$, $p < .001$, $\eta^2 = .702$, and Emotion, $F(3, 48) = 7.51$, $p < .001$, $\eta^2 = .319$, έ = .926, as well as a Task x Emotion interaction, $F(3, 48) = 4.21$, $p = .017$, $\eta^2 = .208$, έ = .798. Participants were faster to find angry faces than scheming or sad faces, and faster to find scheming or sad faces than happy faces, all $t(48) > 2.77$, $p < .05$, whereas there was no difference among the four different stimuli in the feature task, all $t(48) < 1.20$. Overall percentage of errors committed was low, M = 6.51%, SD = 6.93, and did not differ across conditions, largest $F = 1.63$, $p = .213$.

Insert Figure 5 about here

Experiment 5 confirmed the findings of Experiment 3 demonstrating a differential pattern of results for the search for schematic faces and for stimuli comprising only the features that are critical for stimulus discrimination. Whereas the former yielded the face in the crowd effect, faster detection of angry faces, the latter did not. This pattern of results confirms that the failure to find a face in the crowd effect in the Feature task of Experiment 3 does not reflect on the presentation of the stimuli in a regular grid. It also indicates that the faster detection of angry schematic faces does not reflect on the preponderance of inward pointing lines in these faces. After all, the presentation of just these stimulus elements was not sufficient to support a difference in the speed of target detection.

Experiment 6

The results of Experiments 3 and 5 suggest that the addition of eyes and nose elements was required for the face in the crowd effect to emerge. One could argue, however, that the addition of two circles and a triangle enhanced the effects of the inward pointing lines in our schematic faces to the extent that a face in the crowd effect was observed. Experiment 6 was designed to test whether the emergence of the effect is contingent on adding the two circles and the triangle in the positions where eyes and mouth would be expected.

Method

Thirty-three undergraduate psychology students aged between 17 and 28 years (21 female, 12 male; *M* = 20.18 years) volunteered participation. Experiment 6 was run using the same apparatus and procedure as Experiment 1, however, participants were run in groups of up to 6 simultaneously. Participants completed three search tasks comprising the stimuli depicted in rows 11-13 of Figure 1 in counterbalanced order. Data processing and analyses were the same as in Experiment 1.

Results and Discussion

Figure 6 summarises the results of Experiment 6. As can be seen, target detection times differed across stimuli in the face and in the scrambled condition, but not in the feature condition. The 3 x 4 (Task [Feature, Scrambled, Face] x Emotion [Angry, Scheming, Sad, Happy]) factorial ANOVA yielded main effects for Task, $F(2, 64) = 24.68$, $p < .001$, $\eta^2 = .435$, έ

= .783, and Emotion, $F(3, 96) = 26.98$, $p < .001$, $\eta^2 = .457$, έ = .845, as well as a Task x Emotion interaction, $F(6, 192) = 4.24$, $p = .002$, $\eta^2 = .117$, έ = .708. In the face task, participants were faster to find angry and scheming faces than sad or happy faces, all $t(192) > 3.65$, $p < .01$, whereas there was no difference among the four different stimuli in the feature task, all $t(192) < 1.51$. In the scrambled condition, participants were faster to find angry, scheming, and sad faces than happy faces, all $t(192) > 3.01$, $p < .05$. Overall more errors were committed in the detection of happy expressions, M = 9.98%, SD = 8.22, than in the detection of angry, M = 4.21%, SD = 5.67, scheming, M = 5.33%, SD = 5.87, or sad faces, M = 5.61%, SD = 6.36, $F(3, 96) = 19.95$, $p < .001$, $\eta^2 = .384$, έ = .866, all $t(96) > 4.10$, $p < .01$.

The results of Experiment 6 can be taken to suggest that adding two circles and a triangle anywhere in the face stimulus may yield a face in the crowd effect that is not present in absence of these stimuli. However, inspection of the scrambled stimuli used in the experiment suggests that our attempt to avoid the impression of a face may not have been successful. As in a face, the two a circles are still in the left or right half of the face, if at different heights, and the nose is between them. Thus, the scrambled faces retained some of the first order relations among the elements that characterise a face (Maurer, Le Grand, & Mondloch, 2002). Experiment 7 assessed whether the differential detection of the expressions would be still evident if these first order characteristics are disturbed. In order to achieve this, we arranged the two circles and the triangle in a vertical line (see Figure 1, row 15).

Experiment 7

Method

Twenty-five undergraduate psychology students aged between 17 and 25 years (15 female, 10 male; *M* = 19.35 years) volunteered participation. Experiment 7 was run using the same apparatus and procedure as Experiment 6. Participants completed three search tasks comprising the stimuli depicted in rows 14-16 of Figure 1 in counterbalanced order. Data processing and analyses were the same as in Experiment 1.

Results and Discussion

Figure 7 summarises the results of Experiment 7. Target detection times differed across stimuli, with the pattern observed in the face task resembling that seen before. In the scrambled and in the feature condition, detection times seemed variable across emotions, but no difference between happy and angry expressions emerged. The 3 x 4 (Task [Feature, Scrambled, Face] x Emotion [Angry, Scheming, Sad, Happy]) factorial ANOVA yielded main effects for Task, $F(2, 48) = 22.20$, $p < .001$, $\eta^2 = .481$, έ = .940, and Emotion, $F(3, 72) = 6.06$, $p = .007$, $\eta^2 = .202$, έ = .558. Although the Task x Emotion interaction was not significant after Greenhouse-Geisser correction, $F(6, 144) = 2.14$, $p = .123$, $\eta^2 = .082$, έ = .364, it was followed up to assess the presence of differences across expressions in each of the three tasks. The one way ANOVAs in the feature, $F(3, 72) = 1.22$, p = ..294, $\eta^2 = .048$, έ = .460, and scrambled conditions, $F(3, 72) = 1.71$, $p = .198$, $\eta^2 = .067$, έ = .524, yielded no significant differences. In the face task, detection of the happy face was slower than detection of the angry face, t(72) = 3.78, p < .05, main effect Emotion, $F(3, 72) = 8.97$, $p = .001$, $\eta^2 = .272$, έ = .535.

The analysis of the error data yielded a main effect for Emotion, $F(3, 72) = 12.31$, $p = .001$, $\eta^2 = .339$, έ = .422, and a Task x Emotion interaction, $F(6, 144) = 4.29$, $p = .025$, $\eta^2 = .152$, έ = .288. The follow up analyses of the interaction did not yield significant results after correction for multiple testing. Across all tasks, participants committed more errors in the detection of scheming, M = 19.56%, SD = 26.15, than of angry, M = 5.78%, SD = 6.84, or sad faces, M = 7.63%, SD = 8.42, both t(144) > 3.0, p < .01. The high error rates for scheming faces reflect on some participant's poor performance in the feature and scrambled tasks. As the overall pattern of results did not change if these participants were excluded, we decided to report the results from the entire sample.

The results of Experiment 7 suggest that the face in the crowd effect with schematic faces will occur only if the eyes and nose elements are arranged in a manner that is consistent with the placement of eyes and noses. As seen in all previous experiment, the addition of two circles and a triangle, eyes and a nose, to the critical features circumference, mouth, and eyebrows slowed target detection regardless of their arrangement. However, faster detection of angry than of happy configurations was only evident if the additional features were arranged in a manner that retained the first order relations of the elements present within a face (Maurer et al., 2002). It was absent if these relations were disturbed by placing the eyes in a vertical line above and below the nose.

Experiment 8

Experiment 8 was designed to assess whether the repeated failure to find a difference in target detection across emotions in our Feature tasks which is inconsistent with the data reported in Experiments 1 and 2 and by Coelho et al. (2010) may reflects on the relative faintness of the lines used to draw the faces[1]. The stimuli used by Coelho et al. were drawn with rather thick lines and are of higher contrast than are our schematic faces. We assessed this by re-drawing the schematic face stimuli used in Experiment 4 with thicker black lines (see Figure 1, rows 17-18).

Method

Seventeen undergraduate psychology students aged between 17 and 23 years (12 female; *M* = 18.53 years) volunteered participation. Experiment 8 was run using the same apparatus and procedure as Experiment 6 and participants completed two search tasks comprising the stimuli

[1] We would like to thank two reviewers for pointing this out to us.

depicted in rows 17-18 of Figure 1 in counterbalanced order. Data processing and analyses were the same as in Experiment 1.

Results and Discussion

Figure 8 summarises the results of Experiment 8. Target detection times differed across stimuli, with the difference across stimuli observed in the face task being more pronounced than in the feature task. The 2 x 4 (Task [Feature, Face] x Emotion [Angry, Scheming, Sad, Happy]) factorial ANOVA yielded main effects for Task, $F(1, 16) = 55.62$, $p < .001$, $\eta^2 = .777$, and Emotion, $F(3, 48) = 16.95$, $p < .001$, $\eta^2 = .514$, έ = .843, as well as a Task x Emotion interaction, $F(3, 48) = 9.57$, $p < .001$, $\eta^2 = .374$, έ = .878. In the Feature task, angry faces were found faster than sad and happy faces, both $t(48) > 2.57$, $p < .05$. In the face task, angry, scheming, and sad faces were found faster than happy faces, all $t(48) > 5.50$, $p < .01$, and angry faces were found faster than sad faces, $t(48) = 3.44$, $p < .01$. The detection advantage for angry faces relative to happy ones in the face task, M = 137 ms, SD = 97.35, was larger than in the Feature task, M = 43 ms, SD = 37.62, $t(16) = 4.07$, $p = .001$. The analysis of the error data revealed a main effect for Emotion, $F(3, 48) = 4.50$, $p = .011$, $\eta^2 = .220$, έ = .859, with more errors committed in detecting happy, M = 14.54%, SD = 11.37, than angry faces, M = 7.84%, SD = 8.57, $t(48) > 3.0$, $p < .01$.

The results are consistent with the suggestion that a difference in target detection across emotions will be observed in the feature task if the stimuli are drawn with thicker lines and at a higher contrast. Thus, the enhanced clarity of the stimuli led to a detection advantage for angry faces over happy faces. The pattern of results seen in the feature task resembles that of Experiment 1 in both the size of the overall detection advantage for angry faces, 36 ms in Experiment 1, 43 ms in Experiment 8 as well as in the overall level of task difficulty as indicated by average detection time. It differs, however, in that the addition of eyes and noses led to an enhancement of the anger detection advantage in Experiment 8. A similar increase was not observed by Coelho et al. (2010) when the cross stimuli were changed to faces by adding eyes and replacing the two lines representing the mouth with a single, curved line. Rather, the detection advantage for face stimuli was smaller than that observed for the feature stimuli.

General Discussion

The question as to whether preferential detection of some emotional expressions over others in visual search reflects on emotion or on low level perceptual features is long standing and of relevance to studies that use photographic (Purcell, Stewart, & Skov, 1996; Horstmann, Lipp, & Becker, 2012) or schematic representations of faces (Purcell & Stewart, 2010; Coelho et al., 2010). The current research addresses this question in the domain of research with schematic faces by making two contributions. First, it replicated a finding reported by Coelho et al. (2010) that schematic face like stimuli with a preponderance of inward pointing lines are detected faster than stimuli with predominately radial patterns in a search procedure that does not confound background and target stimuli. This was achieved in Experiments 1 and 2 using a variable target search paradigm in which stimuli comprising different arrangements of inward pointing and radial lines were presented among a constant set of background stimuli. Stimuli with four inward pointing lines, an analogue of angry schematic faces, were found faster than stimuli with a radial arrangement, analogues of happy schematic faces, with detection times for analogues for scheming and sad faces in between. These results could be taken to suggest that a preponderance of inward pointing lines may explain the faster detection of angry schematic faces. However, results of Experiment 2a suggest that this only holds if the stimuli also have a circular circumference. Removal of the circumference eliminated the differential target detection across stimuli.

Second, the current research was to assess whether a similar detection advantage will be observed with stimuli that comprise only those elements of schematic faces, upturned mouths and inward pointing eyebrows, which are thought to mediate the faster detection of angry faces according to the alternative explanation offered by Coelho et al. (2010). If the detection advantage for angry schematic faces indeed reflects on the preponderance of inward pointing lines, then it should be evident with stimuli that comprise only these elements, the elements that the stimuli used in Experiments 1 and 2 were designed to represent. This was not the case. The detection time for stimuli consisting of only the circumference, eyebrows, and mouths did not differ across configurations in Experiments 3, 5, 6 and 7, even when the eyebrows were lowered to resemble eyes. Such a difference across stimuli did emerge, however, when only eyes (Experiment 4) or eyes and noses were added; face tasks in Experiments 3-7. It also emerged if the added eyes and nose stimuli were presented in locations that are unusual, but maintain the first order relations of the elements present in a human face (Task Scrambled in Experiment 6). It was absent if these first order relations were violated by vertically aligning the two eyes above and below the nose (Task Scrambled in Experiment 7). This pattern of results suggests that a preponderance of inward pointing lines in the angry faces used here is not sufficient to explain the detection advantage they show in visual search. Rather, the current results indicate that with the schematic faces shown in Figure 1, a detection advantage for angry faces emerges only if the stimulus is perceived as a face, see stimuli in rows 5, 7, 8, 9, 10 and 13, and to some extent 11, but not if only the critical elements, eyebrows and mouth, are presented. This can be altered if the schematic face stimuli are made more salient by drawing them with thicker lines and higher contrast to resemble the stimuli used by Coelho et al. (2010; see Figure 1 lines 16 and 17). Now, the features representing angry expressions were found faster than the ones representing happy expressions. The pattern of results in this feature task resembles that seen in Experiment 1 closely, both in terms of average time needed to detect the targets as well as in the size and direction of the differences observed. Adding eyes and noses, however, amplified this pattern of results such that the difference in detecting angry and happy faces increased significantly and that differences in the detection time for other expressions emerged as well. The former enhancement was not seen by Coelho et al. (2010).

The current results are also inconsistent with the explanation offered by Purcell and Stewart (2010) for the face in the crowd effect observed with schematic faces. The feature stimuli used in Experiments 3 and 5-7 retained the interactive relationship between eyebrows, mouths, and circumference that was suggested to form conforming or non-conforming sub configurations. Nevertheless, no difference in target detection was observed. It seems unlikely that minor differences in procedure can account for the differences in results; Purcell and Stewart used a go/no go procedure in which participants initiated each trial in contrast to the computer paced 2AFC procedure used here. However, it should be noted that the non-emotional face stimuli used by Purcell and Stewart retained their appearance as faces whereas our feature stimuli did not. In any case, the present results seem to suggest that it is not possible to interpret previous reports of detection differences among schematic emotional faces as reflecting entirely on the effects of low level perceptual features, preponderance of inward pointing lines or interactive relationship between eyebrows, mouths, and circumference.

References

Becker, D. V., Anderson, U. S., Mortensen, C. R., Neufeld, S. L., & Neel, R. (2011). The Face in the Crowd Effect Unconfounded: Happy Faces, Not Angry Faces, Are More Efficiently Detected in Single- and Multiple-Target Visual Search Tasks. *Journal of Experimental Psychology: General, 140,* 637-659. doi: 10.1037/a0024060

Calvo, M. G., Avero, P., & Lundqvist, D. (2006). Facilitated detection of angry faces: Initial orienting and processing efficiency. *Cognition & Emotion, 20*(6), 785-811. doi: 10.1080/02699930500465224

Coelho, C. M., Cloete, S., & Wallis, G. (2010). The face-in-the-crowd effect: When angry faces are just cross(es). *Journal of Vision, 10,* 1–14. doi: 10.1167/10.1.7.

Forster, K. I., & Forster, J. C. (2003). DMDX: A Windows display program with millisecond accuracy. *Behavior Research Methods, Instruments & Computers, 35*, 116-124. doi: 10.3758/BF03195503

Frischen, A., Eastwood, J. D., & Smilek, D. (2008). Visual search for faces with emotional expressions *Psychological Bulletin, 134,* 662-676. doi: 10.1037/0033-2909.134.5.662

Hansen, C. H., & Hansen, R. D. (1988). Finding the face in the crowd: An anger superiority effect. *Journal of Personality and Social Psychology, 54,* 917-924. doi: 10.1037/0022-3514.54.6.917

Horstmann, G. (2007). Preattentive face processing: What do visual search experiments with schematic faces tell us? *Visual Cognition, 15,* 799-833. doi: 10.1080/13506280600892798

Horstmann, G. (2009). Visual search for schematic affective faces: Stability and variability of search slopes with different instances. *Cognition & Emotion, 23,* 355-379. doi: 10.1080/02699930801976523

Horstmann, G., Scharlau, I., & Ansorge, U. (2006). More efficient rejection of happy than of angry face distractors in visual search. *Psychonomic Bulletin & Review, 13*, 1067-1073. doi: 10.3758/BF03213927

Horstmann, G., Lipp, O. V., & Becker, S. I. (2012). Of toothy grins and angry snarls – Open mouth displays contribute to efficiency gains in search for emotional faces. *Journal of Vision, 12*, 1-15. doi: 10.1167/12.5.7

Lipp, O. V., Price, S. M., & Tellegen, C. L. (2009). No effect of inversion on attentional and affective processing of facial expressions. *Emotion, 9*, 248-259. doi: 10.1037/a0014715

Lipp, O. V., Price, S. M., & Tellegen, C. L. (2009). Emotional faces in neutral crowds: Detecting displays of anger, happiness, and sadness on schematic and photographic images of faces. *Motivation and Emotion, 33*, 249-260. doi: 10.1007/s11031-009-9136-2

Maurer, D., Le Grand, R., & Mondloch, C. J. (2002). The many faces of configural processing. *Trends in Cognitive Sciences, 6*, 255-260.

Nothdurft, H.-C. (1993). Faces and facial expressions do not pop out. *Perception, 22*(11), 1287-1298. doi: 10.1068/p221287

Öhman, A., Lundqvist, D., & Esteves, F. (2001). The face in the crowd revisited: A threat advantage with schematic stimuli. *Journal of Personality and Social Psychology, 80*(3), 381-396. doi: 10.1037/0022-3514.80.3.381

Purcell, D. G., & Stewart, A. L. (2010). Still another confounded face in the crowd. *Attention, Perception & Psychophysics, 72*(8), 2115-2127. doi: 10.3758/APP.72.8.2115

Purcell, D. G., Stewart, A. L., & Skov, R. B. (1996). It takes a confounded face to pop out of a crowd. *Perception, 25*, 1091-1108. doi: 10.1068/p251091

Rohlf, F.J., & Sokal, R.R. (1995). *Statistical tables (3rd ed.).* New York: Freeman.

Savage, R. A., Lipp, O. V., Craig, B. M., Becker, S. I., & Horstmann, G. (2013). In search of the emotional face: Anger versus happiness superiority in visual search. *Emotion. Advance online publication*. doi: 10.1037/a0031970

Whitney, D., & Levi, D. M. (2011). Visual crowding: a fundamental limit on conscious perception and object recognition. *Trends in Cognitive Sciences, 15*(4), 160-168. doi: 10.1016/j.tics.2011.02.005

Figure captions

Figure 1: Stimuli used as targets and backgrounds in Experiments 1-8.

Figure 2: Target detection time for line configurations representing angry, scheming, sad, and happy faces in Experiments 1 (upright stimuli – Figure 1, row 1), 2 (tilted stimuli - Figure 1, rows 2 and 3) and 2a (upright stimuli without circumference – Figure 1, row 4; error bars represent standard errors of the mean).

Figure 3: Target detection time for the critical features of angry, scheming, sad, and happy schematic faces (see Figure 1, row 6) and for schematic emotional faces (see Figure 1, row 5) in Experiment 3 (error bars represent standard errors of the mean).

Figure 4: Target detection time for angry, scheming, sad, and happy schematic faces with eyes only (see Figure 1, row 8) and eyes and noses (see Figure 1, row 7) in Experiment 4 (error bars represent standard errors of the mean).

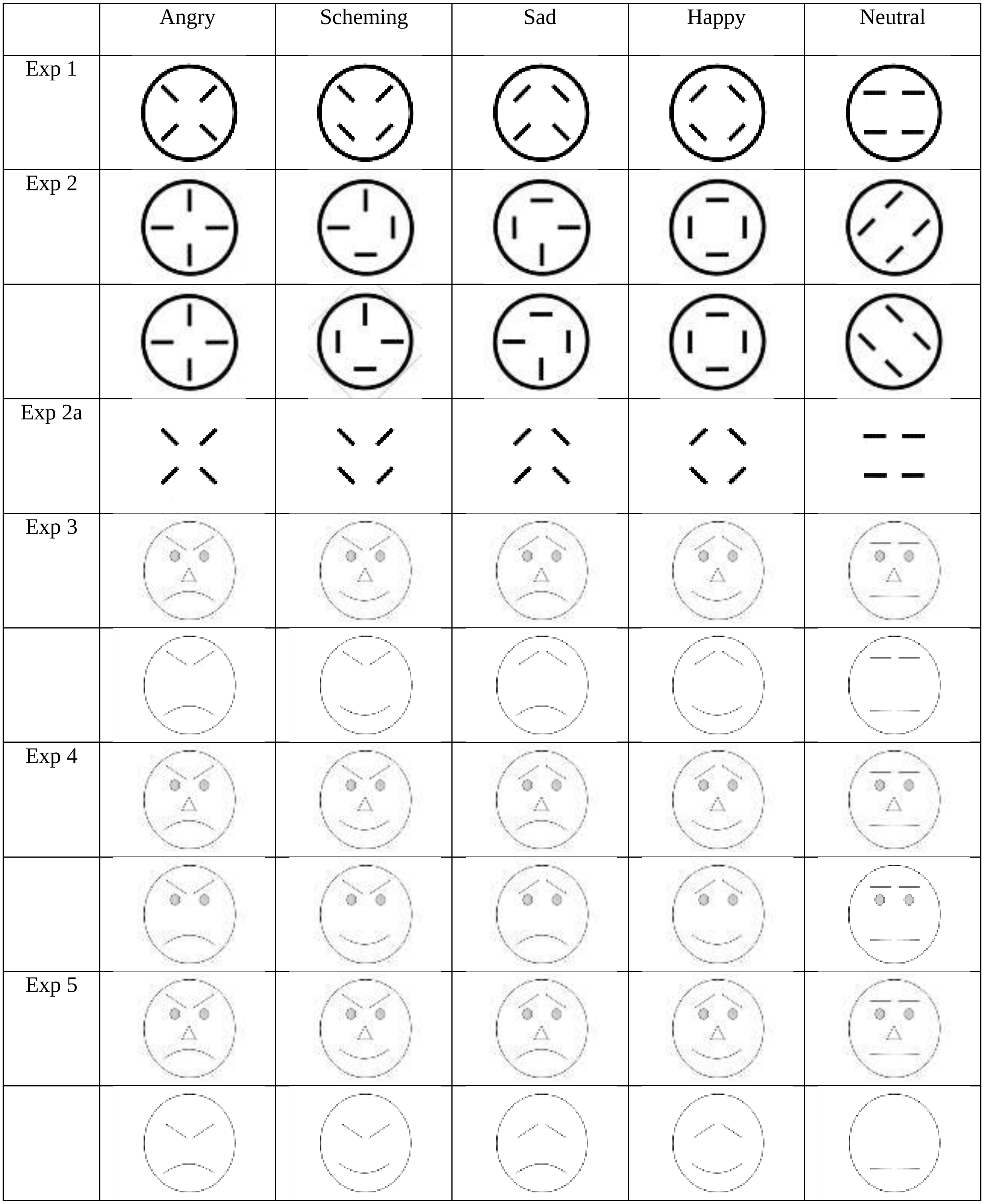
Figure 5: Target detection time for the critical features of angry, scheming, sad, and happy schematic faces with lowered eyebrows (see Figure 1, row 10) and for schematic emotional faces (see Figure 1, row 9) in Experiment 5 (error bars represent standard errors of the mean).

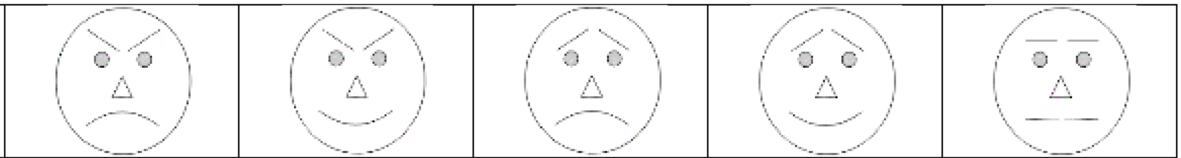
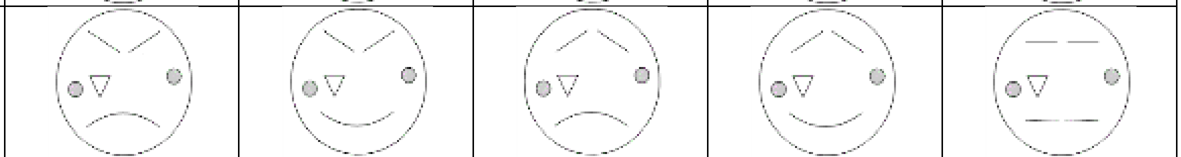
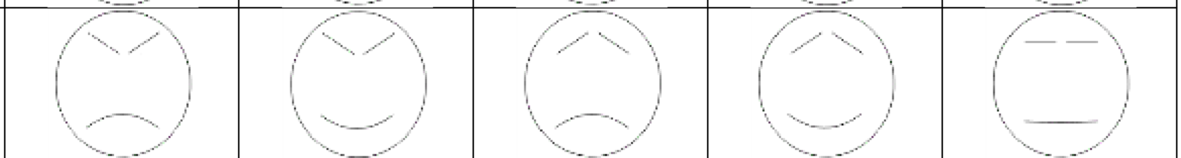
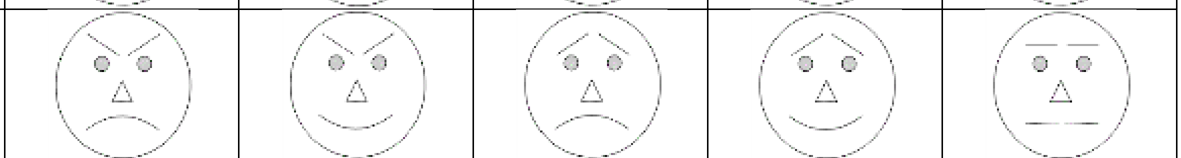
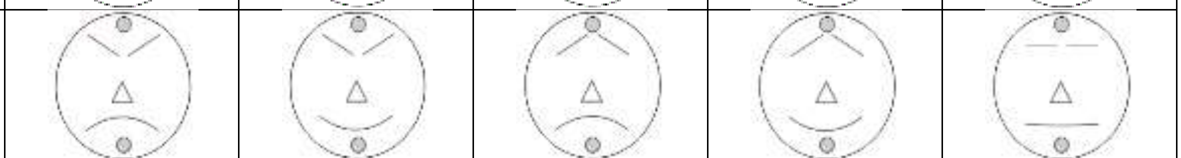
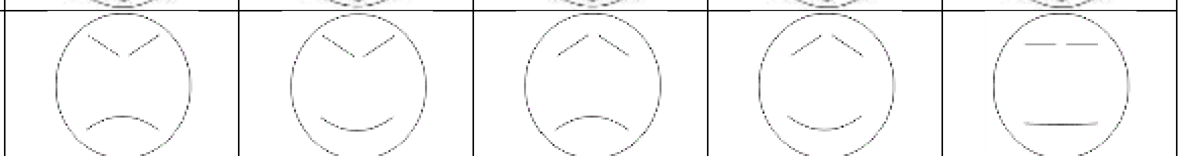
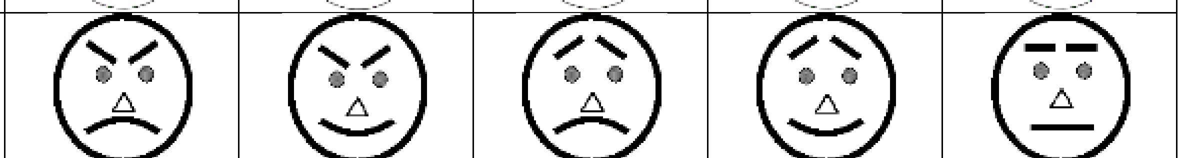
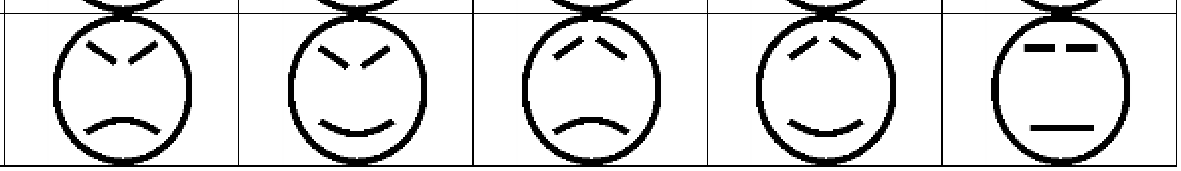
Figure 6: Target detection time for the critical features of angry, scheming, sad, and happy schematic faces (see Figure 1, row 13), for scrambled schematic emotional faces (see Figure 1, row 12), and for schematic emotional faces (see Figure 1, row 11) in Experiment 6 (error bars represent standard errors of the mean).

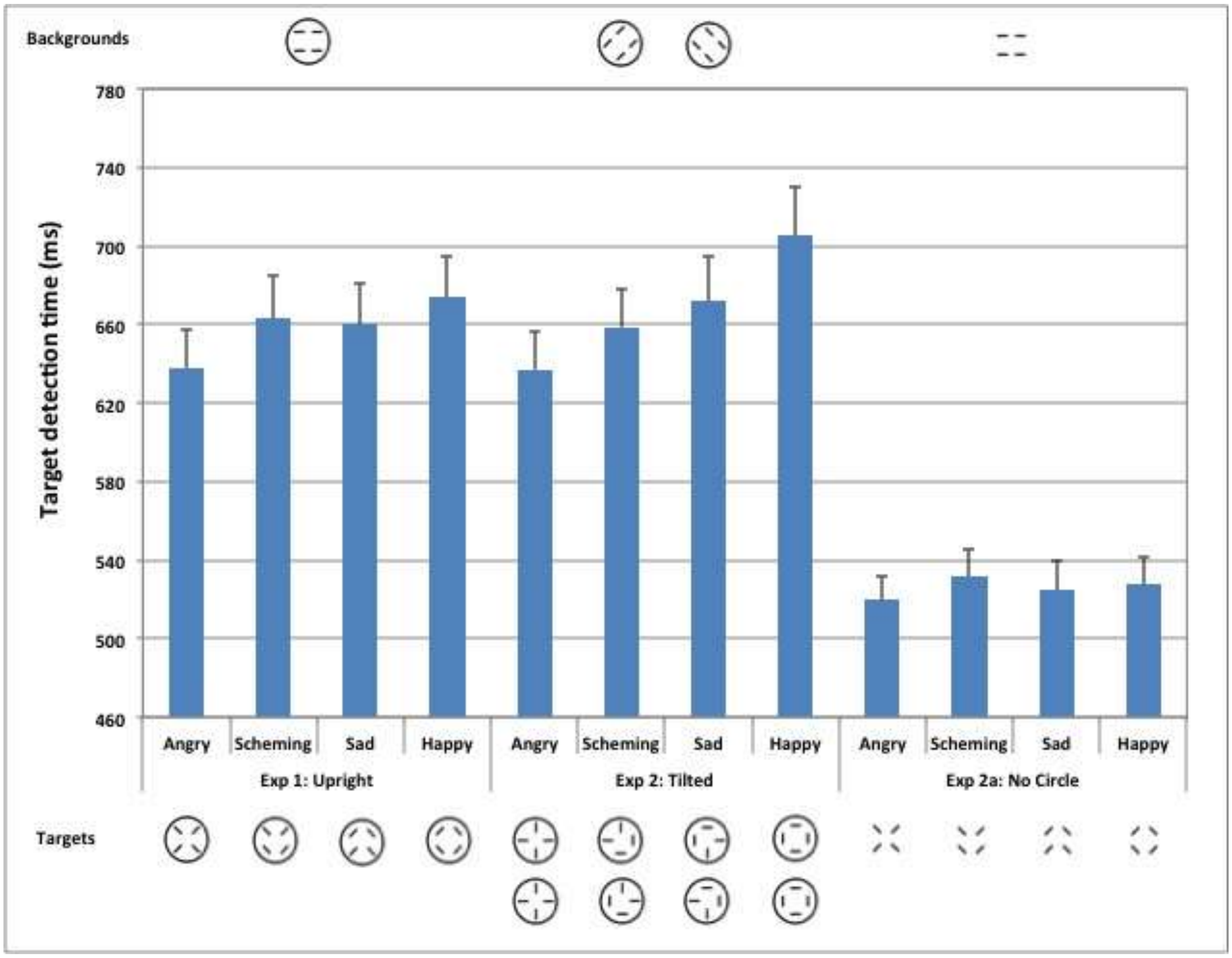
Figure 7: Target detection time for the critical features of angry, scheming, sad, and happy schematic faces (see Figure 1, row 16), for scrambled schematic emotional faces (see Figure 1, row 15), and for schematic emotional faces (see Figure 1, row 14) in Experiment 6

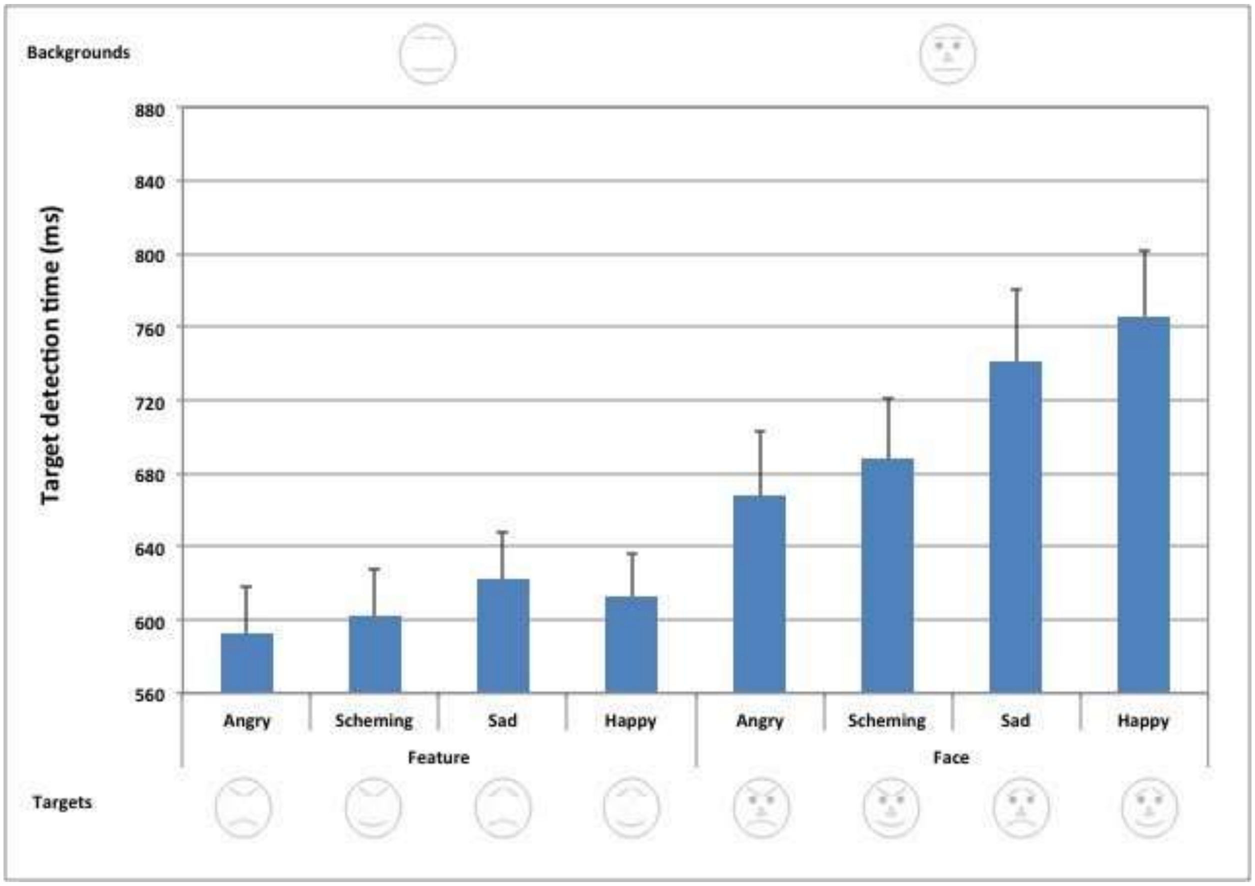
(error bars represent standard errors of the mean).

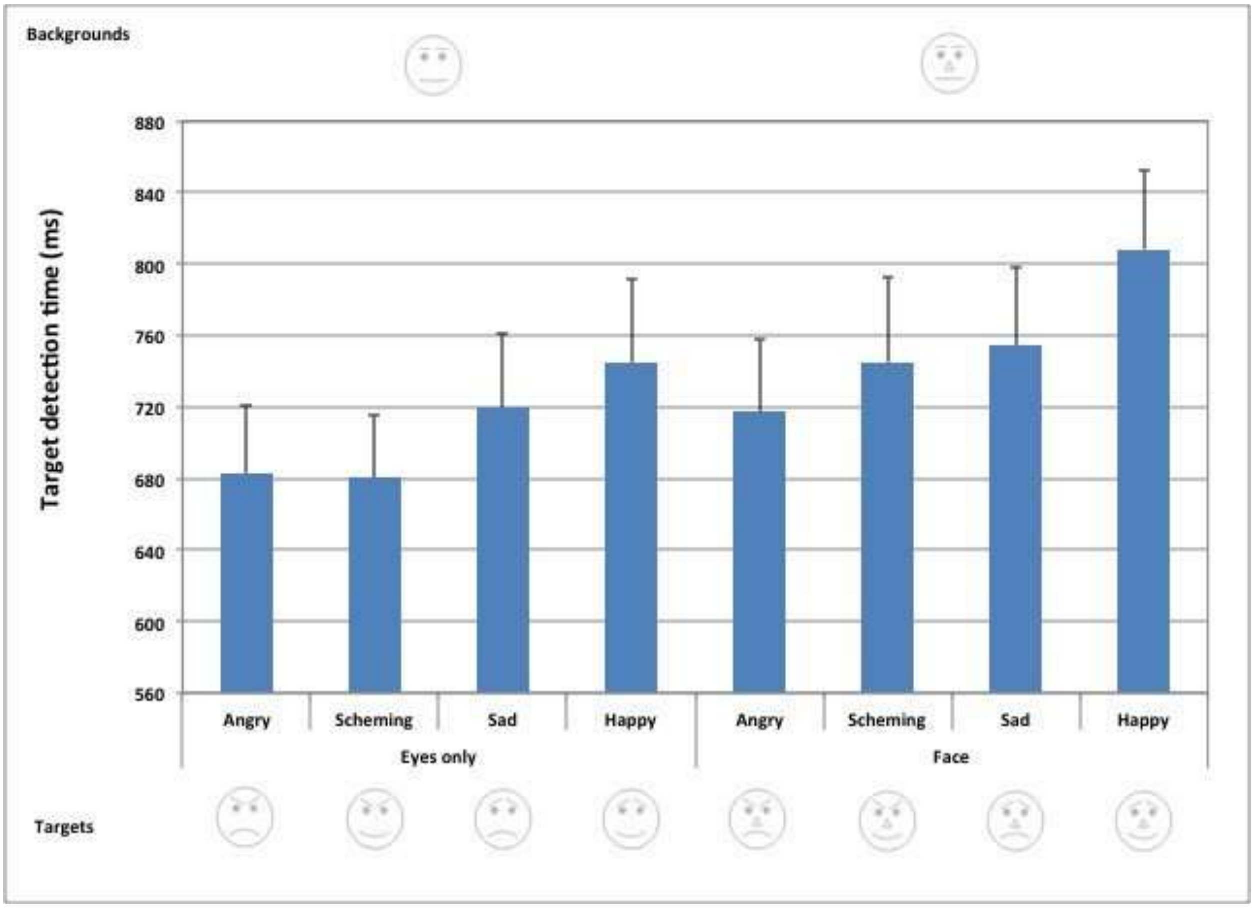
Figure 8: Target detection time for the critical features of angry, scheming, sad, and happy schematic faces (see Figure 1, row 18) and for schematic emotional faces (see Figure 1, row 17) drawn with thicker black lines in Experiment 8 (error bars represent standard errors of the mean).

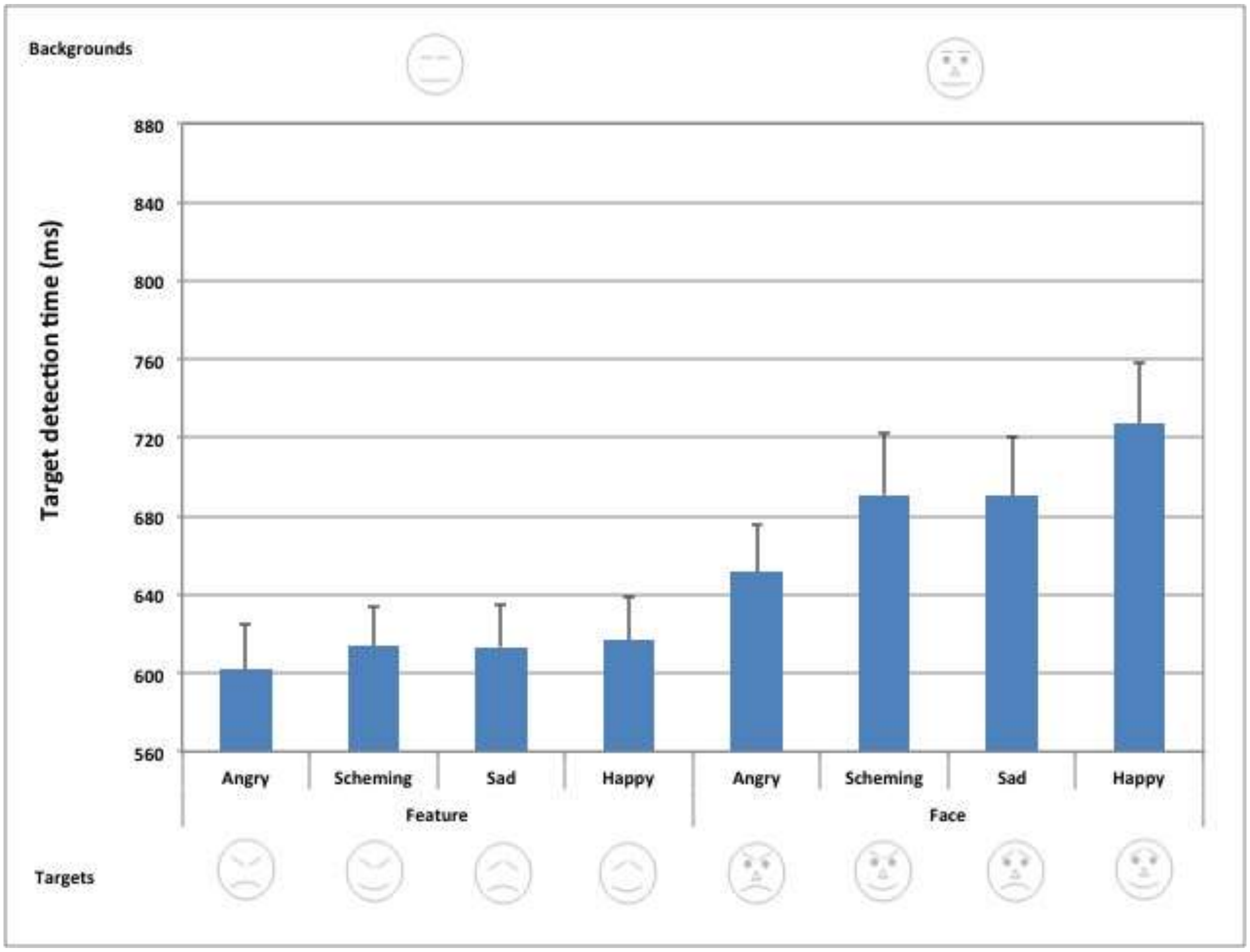

Angry
Scheming
Sad
Happy
Neutral
Exp 1
Exp 2
Exp 2a
Exp 3
Exp 4
Exp 5

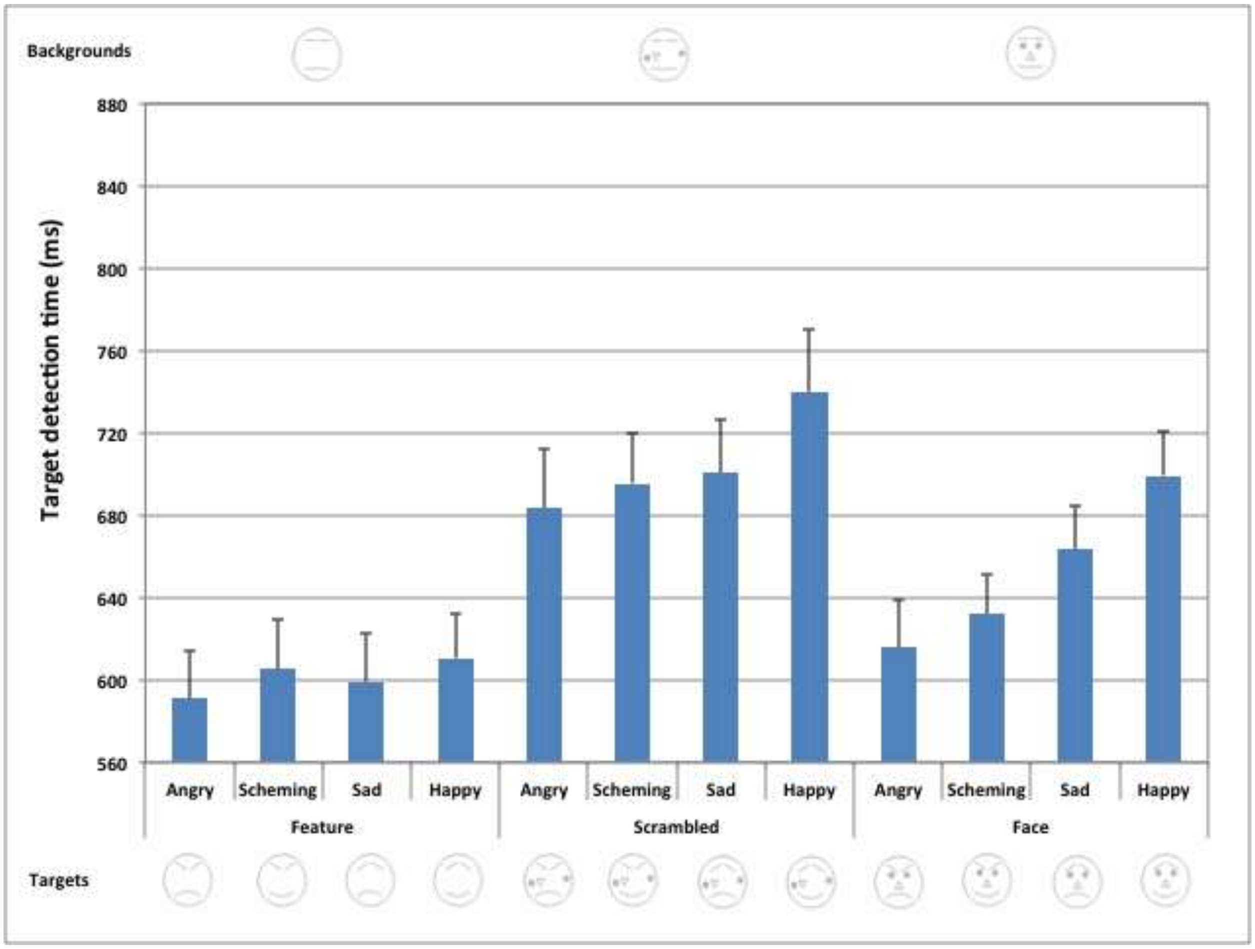
Exp 6	
	
	
Exp 7	
	
	
Exp 8	
	

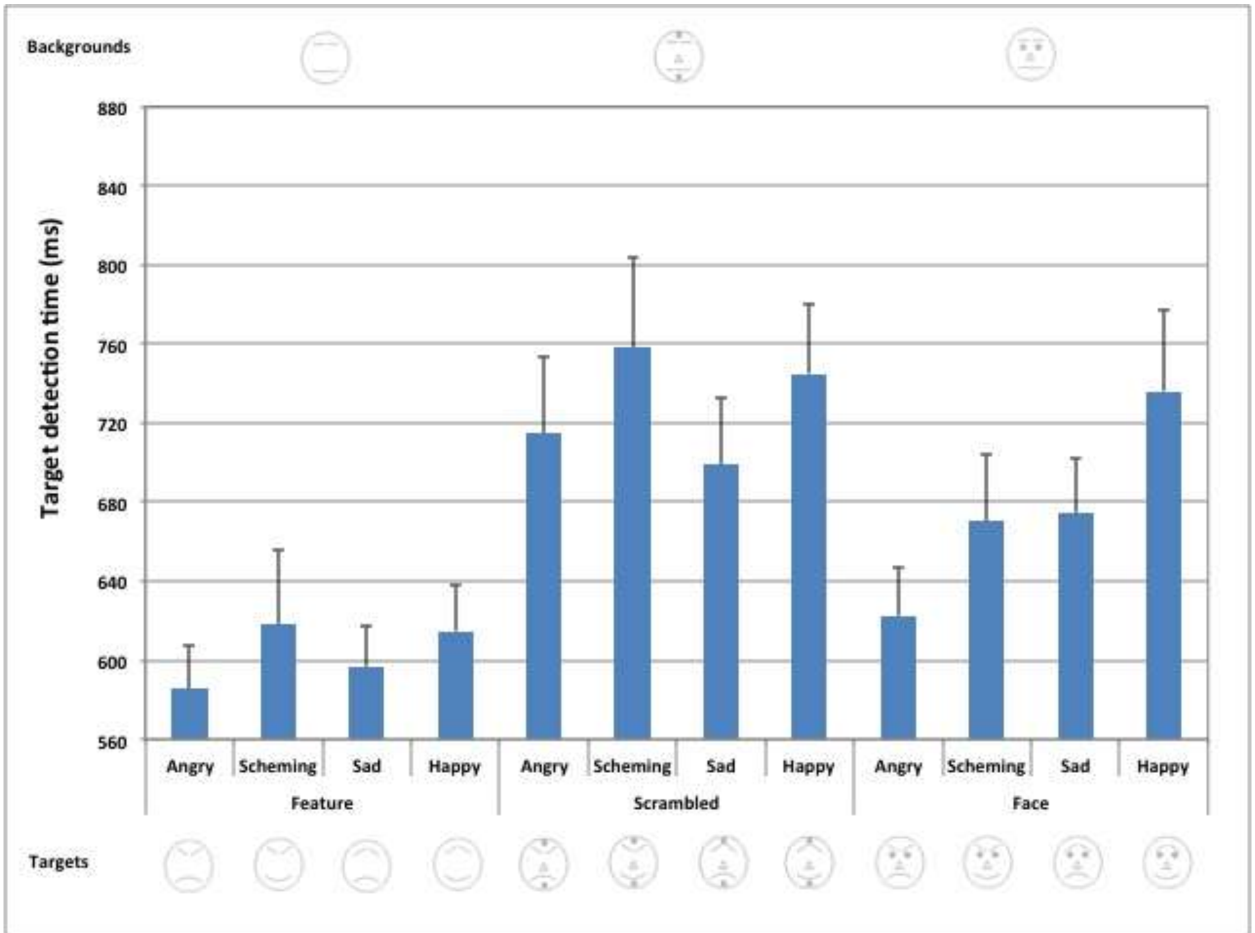

Backgrounds
Target detection time (ms)
780
740
700
660
620
580
540
500
460
Angry
Scheming
Sad
Happy
Exp 1: Upright
Angry
Scheming
Sad
Happy
Exp 2: Tilted
Angry
Scheming
Sad
Happy
Exp 2a: No Circle
Targets

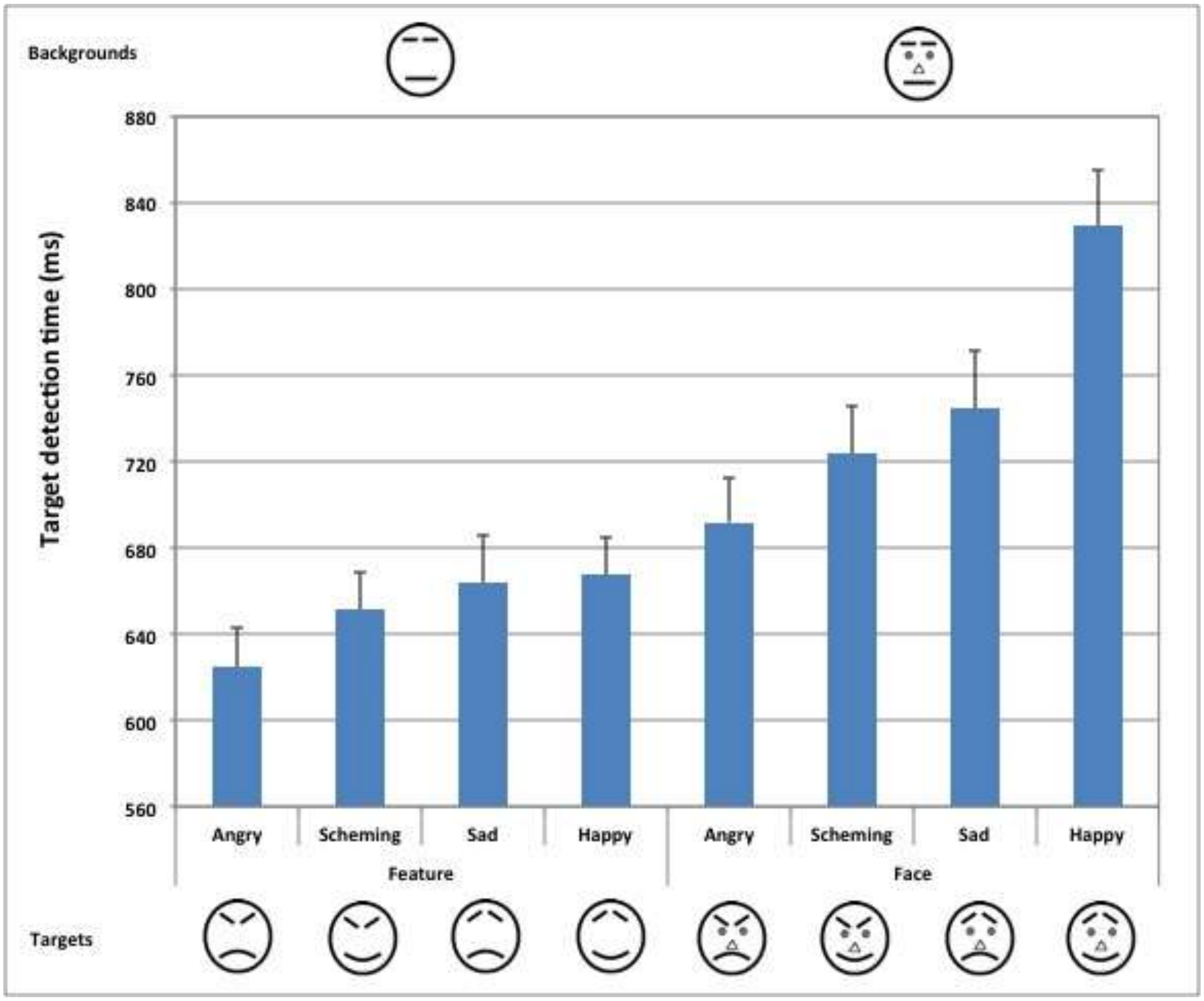

Backgrounds
Target detection time (ms)
880
840
800
760
720
680
640
600
560
Angry
Scheming
Sad
Happy
Angry
Scheming
Sad
Happy
Feature
Face
Targets


Backgrounds
Target detection time (ms)
880
840
800
760
720
680
640
600
560
Angry
Scheming
Sad
Happy
Angry
Scheming
Sad
Happy
Eyes only
Face
Targets


Backgrounds
Target detection time (ms)
880
840
800
760
720
680
640
600
560
Angry
Scheming
Sad
Happy
Angry
Scheming
Sad
Happy
Feature
Face
Targets


Backgrounds
Target detection time (ms)
880
840
800
760
720
680
640
600
560
Angry
Scheming
Sad
Happy
Angry
Scheming
Sad
Happy
Angry
Scheming
Sad
Happy
Feature
Scrambled
Face
Targets


Backgrounds
Target detection time (ms)
880
840
800
760
720
680
640
600
560
Angry
Scheming
Sad
Happy
Angry
Scheming
Sad
Happy
Angry
Scheming
Sad
Happy
Feature
Scrambled
Face
Targets


Backgrounds
880
840
800
760
720
680
640
600
560
Target detection time (ms)
Angry
Scheming
Sad
Happy
Angry
Scheming
Sad
Happy
Feature
Face
Targets