Still Another Confounded Face in the Crowd

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Running head: A420RA A face confound

Abstract

Experiments using schematic faces developed by Öhman seem to document an anger-superiority effect, although we have come to question these experiments. Our work shows that the low-level features of these schematic faces interact with the face's surround to produce the effects that have been attributed to facial affect. Using relatively neutral faces that preserved the feature and surround spatial relationships of angry and happy schematic faces we produced response times indistinguishable from those found with angry and happy faces. We also found that the target face's position within the crowd determined the magnitude of the advantage for angry faces as well as for relatively affect-neutral faces. Removing the facial surround reduces the advantage for angry faces largely by improving performance on happy faces. There was an apparent small advantage for angry features without a surround. Öhman faces avoid the problems associated with modified grayscale faces only to introduce an equally troubling confound.

Key words: emotions, facial expression, visual search, reaction time

Still Another Confounded Face in the Crowd

An impressive number of studies claim angry expressions accelerate visual search for an angry face located within a crowd of happy or neutral faces (Gilboa-Schectman, Foa & Amir, 1999; Fox, Lester, Russo, Bowles, Pichler & Dutton, 2000; Öhman, Lundqvist, & Esteves, 2001; Eastwood, Smilek, & Merikle, 2001; Lundqvist & Öhman, 2005; Schubo, Gendolla, Meinecke, & Abele, 2006; Williams & Mattingley, 2006). This finding is sometimes referred to as the *anger-superiority effect* (ASE) although angry faces are not always associated with superior performance. A briefly presented angry face retards identification of affect more than does a single happy face. This *anger-inferiority effect* (AIE) occurs with grey-scale faces (Shimoda, Argyle & Bitti, 1978; Boucher & Carlson, 1980; Pizzamiglio, Zoccolotti, Mammucari & Cesaroni, 1983; Kirouac & Dore, 1984; 1985; Mandal & Palchoudhury, 1985; Stalans & Wedding, 1985; McAndrew, 1986; Wagner, MacDonald & Manstead, 1986; Harrison, Gorelczenko & Cook, 1990; Srivastava & Mandal, 1990; Purcell, Stewart & Skov, 1998; Leppanen, Tenhunen & Hietanen, 2003; Juth, Lundqvist, Karlsson & Öhman, 2005, Exp-4A). The AIE also occurs with schematic faces (Eastwood, Smilek & Merikle, 2003; Purcell & Stewart, 2003). There is even evidence for an anger-inferiority effect when searching for an angry target face in a crowd of happy or neutral faces (Purcell, Stewart & Skov, 1996; Obrecht & Purcell, 2005; Juth et al., 2005; Calvo & Nummenmaa, 2008). This presents an antinomy where angry faces both facilitate and impede visual search. That or the ASE is found only when a feature renders the angry face more conspicuous than the happy face (Calvo & Nummenmaa, 2008).

A well known example is the experiment of Hansen and Hansen (1988). Digitized grayscale pictures of happy and angry faces were filtered to produce stark black and white representations. The filter's thresholding algorithm inadvertently produced a black splotch just beneath the chin of the angry female face and darkened the angry male face. Observers relied on these dark areas to guide them to the angry face. An AIE was found when the dark areas were removed (Purcell & Stewart, 1996).

To avoid the peril associated with image processing of grayscale pictures many investigators turned to schematic faces (Fox et al., 2000; Eastwood et al., 2001; Öhman et al., 2001; Lundqvist & Öhman, 2005). We have come to believe that these schematic stimuli are also flawed because of the way low-level visual features represent anger and happiness. The lines representing the eyebrows and mouth of a schematic face interact with the surround representing the head (Calvo & Nummenmaa, 2008; Coelho, Cloete & Wallis, 2010; Purcell & Stewart 2002; 2005; 2006). The resulting interplay of low-level visual elements guide an observer's visual search, not the emotion represented by the lines.

Rationale and stimuli

To explore the visual interaction of eyebrows and mouth with their surround we used angry and happy schematic faces based on Öhman's stimuli. We compared these faces to affect-neutral stimuli derived from Öhman's face stimuli. The Öhman faces are designed to be equally discriminable from a schematic neutral face, and they are (Lundqvist, Esteves & Öhman,1999; Exp. 1 of this paper). Our affect-neutral stimuli are designed to keep the relationship between the facial surround and the facial features the same as that for Öhman faces while minimizing their emotional impact. (Exp. 1 of this paper). Our concern is with the visibility of the face when it is projected briefly to retinal points surrounding the macula, where acuity decreases rapidly. A glance at Figure 1 illustrates a troublesome difference between angry and happy stimuli. For the happy face the upturned mouth and the down ward turned eyebrows seems to conform to the ovoid surround of the head (we will refer to these features as conforming/happy). For the angry face the mouth's downturned ends are directed at the head's surround. The upward slanting eyebrows project toward the head's egg-shaped surround and are almost orthogonal to the surround (we refer to these features as nonconforming/angry).

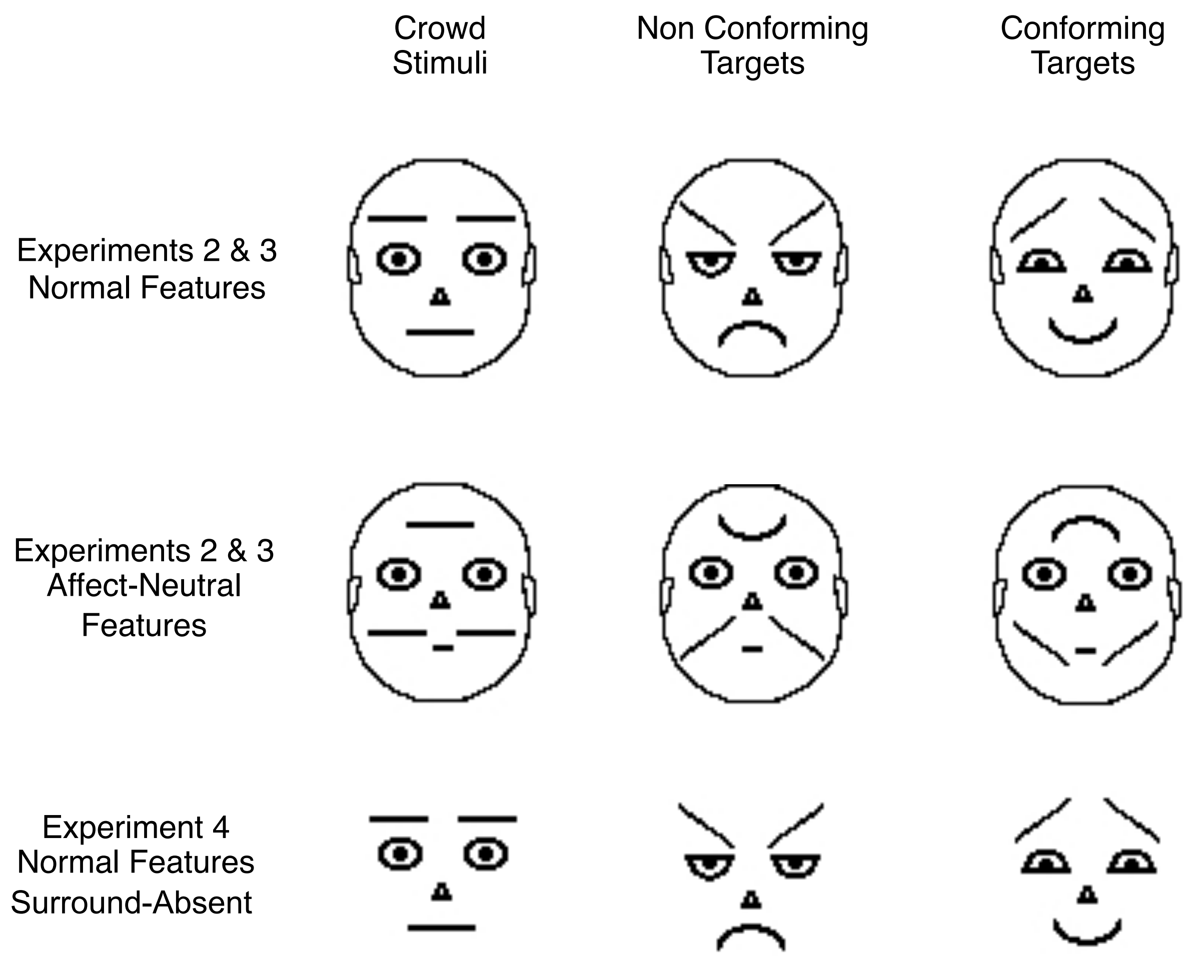

Figure 1. **In Experiment 1 these faces were rated for the degree to which they represent happyness or anger.**

Consider how differences between these angry and happy faces play out as the stimuli are presented to different retinal locations. At the fovea, where resolution is best, happy and angry faces should be equally discriminable from neutral faces. Because the conforming/happy features are closer to the face's ovoid surround, however, placing a happy face away from the fovea, where acuity begins to decrease rapidly, causes the image to become less distinct. At these locations the visual system creates a blurred image causing the eyebrows and mouth of the happy faces to become indistinct from the contour of the surrounding ovoid, making it more difficult to discriminate happy faces from neutral faces. This is less true for the nonconforming/angry faces. Because the angry features do not conform to the facial surround the blurring that occurs at eccentric retinal locations will not cause the features to blend into the facial surround as readily as with conforming/happy features. Consequently nonconforming/angry features will be more conspicuous than conforming/happy features when they are presented farther and farther from the fovea.

The less conspicious the conforming/happy features the more difficult it is to locate a happy face (Öhman et al., 2001, Exp. 2). Response times are faster for a two-by-two array of faces (subtending 7×7 deg of visual angle) than with a five-by-five array (subtending 19×20.5 deg of visual angle). For the larger array the time to locate a happy face is slowed and misses increase. Reaction time to faces increases with increasing retinal excentricity if the size of the face is not increased to compensate for its more eccentric location (Rousselet, Husk, Bennett & Sekuler, 2005). For the two-by-two displays used by Öhman et al (2001) the stimuli above and below fixation would have to be increased in size by a factor of 2.02, while stimuli directly left and right of fixation would have to be increased in size by a factor of 1.95, to be equally visible. Stimuli on the corners of the display would have to be increased by a factor of 2.4. For Öhman's five-by-five displays these factors would be 3.79, 3.59 and 4.81.

Our view is that both angry and happy faces become more and more blurred with each increase of retinal eccentricity but there is a disproportionate loss of legibility for a happy face as its conforming features are blurred with the head's surround. We believe the disproportionate blurring of its features cause a happy face to be differentiated less quickly from the neutral distractors than an angry face, not the differences in emotion conveyed by the visual features. Three predictions are consistent with this argument. (1) Search times should increase as happy and angry faces are presented farther and farther from the fovea. (2) Faces with conforming features will be at a disadvantage when compared with nonconforming features even when these altered faces are judged to be relatively affect neutral (Figure 1). The greatest disadvantage for the conforming/happy face should occur at positions farthest from fixation. In short, the ASE results from that fact that it is more difficult to search for a conforming happy face than for a nonconforming angry face.

The third prediction is even more direct. (3) Removing the facial surround allows the otherwise conforming features to become distinct elements, no more susceptible to the effects of blurring than the nonconforming features of the angry face. The response times to happy and angry faces will become similar to the extent that the ASE is produced by facial features interacting with their surround, and the evidence for an ASE should melt away. While we focus on the specific schematic faces employed by Öhman and his colleagues it would be surprising if our analysis did not apply to various other schematic faces used in crowd search experiments (e.g. Fox et al., 2000; Eastwood et al., 2001; Horstmann, 2007; Horstmann & Becker, 2008; Tipples, Atkinson & Young, 2002).

Experiment 1A: Affect rating

Any discussion of affect and search begins with how well a stimulus face represents an emotion. An anger-superiority effect requires that fast seach times are associated with angry faces while a pseudo-ASE is associated with nonconforing features that are not seen as an angry face. Each of our stimuli were therefore rated on how happy or angry they appeared.

Method

Participants. Thirty-three undergraduates volunteered to serve as raters as part of their introductory psychology course. Participants provided informed consent as required by the Institutional Review Board of Oakland University. Two raters were dropped from data analysis because their ratings indicated that they reversed the rating scale.

Apparatus and Stimuli. The nine individual faces used in Experiments 2, 3, and 4 were centered on nine 8 ½ by 11 inch sheets of paper. Each face subtended 1.5 cm wide by 2.76 cm high. The numbers 1 through 10 were printed at the top of each stimulus sheet. The phrase "Very Happy" was printed to the left of the numeral 1 and the phrase "Very Angry" was printed to the right of the numeral 10. A 25 cm line represented the rating scale, with numbers 1 through 10 evenly spaced along line. These rating sheets were assembled into stacks that were randomly ordered for each rater.

Procedure. Raters were given a stack of nine rating sheets. They were given the following instructions: "You will be looking at line drawings of different faces that will range from happy to angry. We want you to rate them as to how they appear. Your task is to judge the expressions on these faces by circling the number at the top of the page that you feel most closely represents the displayed expression." Ratings were self paced.

Results and Discussion

Individual analyses were conducted on each of the three face types (Öhman-Feature, Affect-Neutral, Surround-Absent Öhman-Feature) used in each of the three visual search experiments. Figure 2 shows the affect ratings for the three types of stimuli.

The Affect-Neutral faces of Experiments 2 and 3 gave a small main effect of Feature-Conformation $F(2,60) = 3.56$, $p = .035$, $MSE = 1.52$, $\eta_p^2 = .11$ with the nonconforming stimulus rated as 0.8 scale units more angry than the conforming stimulus (Figure 2). Post hoc tests (Bonferroni corrected) found the small rating difference between conforming and nonconforming faces to be statistically significant ($p = .04$, $r^2 = .09$) with the nonconforming faces rated more angry (5.8) than the conforming faces (5.0). The stimulus used as a distractor in Experiments 2 and 3 was rated at 5.24. This rating did not differ statistically from the ratings for the conforming stimulus ($p = 0$ .88, $r^2 = .007$), nor did it differ from the ratings for the nonconforming stimulus ($p = .17$, $r^2 = .056$).

The Öhman-Feature faces of Experiments 2 and 3 produced much larger rating differences $F(2,60) = 340.07$, $p \leq .0001$, $MSE = .985$, $\eta_p^2 = .92$. Post Hoc tests (Bonferroni corrected) found a large (6.5 scale units) and statistically significant difference between the nonconforming (9.26) and the conforming (2.73) stimuli ($p \leq .0001$, $r^2 = .92$). Unlike our affect-neutral stimuli, both the conforming and nonconforming stimuli were rated significantly different from the distractor (5.34) stimulus ($p \leq .0001$, $r^2 = .64$) and ($p \leq .0001$, $r^2 = .89$) respectively.

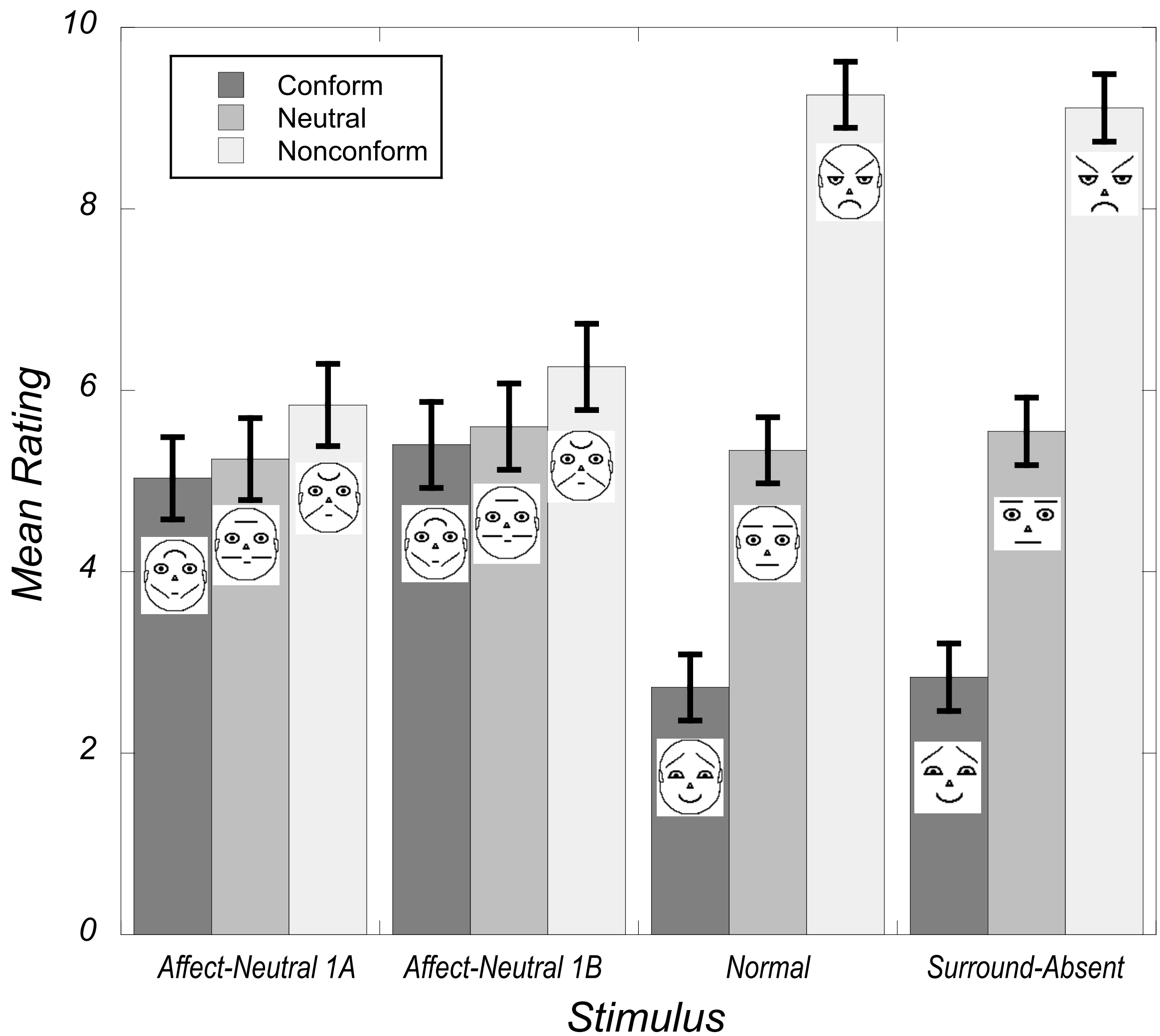

Figure 2. **Shown are rating scores and 95% confidence intervals from Experiments 1A and 1B. These ratings are for the target stimuli (Conforming/happy, Nonconforming/angry) and the crowd stimuli (Neutral) of Experiments 2 & 3 (Affect-Neutral and Normal), and stimuli (Surround-Absent Faces) of Experiment 4. The 95% confidence interval is based on the *MSE* for Feature-Conformation.**

As with normal Öhman-Feature faces, the surround-absent stimuli used in Experiment 4 produced large rating differences with the angry face rated 6.27 scale units more angry than the happy face $F(2,60) = 299.20$, $p \leq .0001$, $MSE = 1.03$, $\eta_p^2 = .91$. Post Hoc tests (Bonferroni correction) found this large difference between the nonconforming (9.11) and the conforming (2.84) stimuli to be statistically significant ($p \leq .0001$, $r^2 = .92$). As with the normal stimuli of

Experiments 2 and 3 both the conforming and nonconforming stimuli were rated significantly different from the distractor (5.55) stimulus ($p \leq .0001$, $r^2 = .65$ and $p \leq .0001$, $r^2 = .76$ respectively).

Experiment 1B: Rating affect-neutral only

In Experiment 1A the ratings of three Affect-Neutral faces differ little while the Öhman-Feature faces are rated as being very different, even when they have no surround. It is possible that if Affect-Neutral faces were rated by themselves they would have been rated as much different from each other, similar to the rating differences seen with Öhman-Feature faces. A second rating experiment was conducted to determine if rating differences between the conforming and nonconforming Affect-Neutral stimuli were compressed by being included with the more extremely rated angry and happy Öhman-Feature faces.

Method

Participants. Forty-four undergraduates volunteered to serve as raters as part of their introductory psychology course. Participants provided informed consent as required by the Institutional Review Board of Oakland University.

Apparatus and Stimuli. The three individual Affect-Neutral faces used in Experiments 2 and 3 were projected on a screen, one at a time. Raters were given response sheets with four rows of the numbers 1 through 10 printed at the top of each sheet. Discriptors anchored each end of the rating scale. Each row corresponded to the following stimulus dimensions: faceness (very unface like to very face like), pleasantness (very pleasant to very unpleasant), activity (very passive to very active) and affect (very happy to very angry). These categories have been used in previous research (Lundqvist, Esteves & Öhman, 1999; Tipples, Atkinson & Young, 2002). We wanted to see how affect judgments with our affect neutral stimuli correlated with them.

Procedure. Raters were run in three seperate groups with each group seeing the three stimuli in a different random order. Raters were given a set of rating sheets. They were given the following instructions: "You will be looking at line drawings of different stimuli. We want you to rate them as to how they appear along the four dimensions on your response sheets. Your task is to judge these stimuli by circling the number in each row that you feel most closely describes the displayed stimulus."

Results and Discussion

The results of Experiment 1B were identical to the Affect-Neutral stimulus results of Experiment 1A. The Affect-Neutral faces of Experiments 2 and 3 gave a statistically significant effect of Feature-Conformation $F(2,86) = 3.68$, $p = .029$, $MSE = 2.44$, $\eta_p^2 = .08$ (Figure 2). Post hoc tests (Bonferroni corrected) found that the small rating difference (0.86 scale points) between conforming and nonconforming faces was statistically significant ($p = .03$, $r^2 = .07$) with the Nonconforming faces rated as slightly more angry (6.26) than the conforming faces (5.39). These findings are identical with those of Experiment 1 with Affect-Neutral stimuli. The stimulus used as the distractor in Experiments 2 and 3 for our Affect-Neutral faces was rated at 5.6. This rating did not differ statistically from the ratings for the conforming stimulus ($p = .90$, $r^2 = .004$), nor did it differ from the ratings for the nonconforming stimulus ($p = .14$, $r^2 = .044$).

Affect ratings were correlated with ratings for Faceness, Pleasantness, and Activity. As expected the correlation of Affect with Pleasantness was statistically significant $r = .52$, $p \leq .0001$ with the more angry a face was rated the more unpleasant it was judged. The correlation of

Affect with Activity was also statistically significant ($r = .27$, $p = .008$) with the more angry a face was judged the more active it was judged. Faceness did not correlate with Affect $r = .003$, $p = .98$.

According to Öhman et al. (2001) the more angry a face the faster an observer will respond to it. If they are correct the ratings generated in Experiments 1A and 1B will predict the response time advantage for faces rated as angry over faces rated as either less angry or as happy. As shown in the following experiments this prediction is only partially supported: affect ratings do not predict the magnitude of the ASE for our Affect-Neutral stimuli nor do they predict the magnitude for surround-absent stimuli. The following search experiments demonstrate that differences in how angry a face appears is only strongly correlated with response times for Öhman-Feature faces with surrounds. The correlation breaks down for Affect-Neutral faces and for surround absent faces.

Experiment 2: A variation of Öhman et al.

We set out to produce a pseudo ASE -- that is, a perceptual advantage for the lines used to draw a face rather than the emotion the features signal. Our first experiment was designed to demonstrate that faces with nonconforming features are located more quickly than those with conforming features even when the features represent neither anger nor happiness. Our experimental manipulation placed both the outgoing and conforming eyebrows and mouths so that they no longer produced happy or angry expressions yet still produce two distinctly different target stimuli: one with conforming features and one with nonconforming features. We compared these Affect-Neutral stimuli to faces used in the Öhman et al. (2001) experiments. The Affect-Neutral condition was designed to demonstrate two things: (1) That relatively neutral stimuli with nonconforming features are located as quickly as Öhman-Feature angry faces. (2) That relatively neutral stimuli with conforming features are just as perceptually disadvantaged as Öhman-Feature happy faces. Both the Affect-Neutral and Öhman-Feature stimuli can be seen in Figure 1.

We treated Feature-Conformation (conforming/happy vs nonconforming/angry) and Retinal-Position as within-observer variables. Nonconforming/angry features were compared to conforming/happy features across nine retinal positions. Feature-Organization is a between-observer variable with two levels: Öhman-Features derived from the Öhman et al (2001) stimuli are compared to our Affect-Neutral target stimuli (Figure 1).

Observers were told to look at a briefly flashed array of faces. They were told that if an array contained a face that differed from the other faces in the array they were to depress a response key, otherwise they were to make no response. The retinal position of stimuli was varied to see if search times and the ASE increase for stimuli presented farther from the fovea. Our conforming and nonconforming stimuli were presented in a 3×3 matrix of faces shown in Figure 3.

Method

Participants. Thirty-four undergraduates volunteered to serve as observers as part of their introductory psychology course. Participants provided informed consent as required by the Institutional Review Board of Oakland University. Seventeen observers were used in the Affect-Neutral condition of Experiment 2 and 17 different observers were used in the Öhman-Feature condition of Experiment 2. One observer was dropped from each condition because of false-alarms greater than 10 percent.

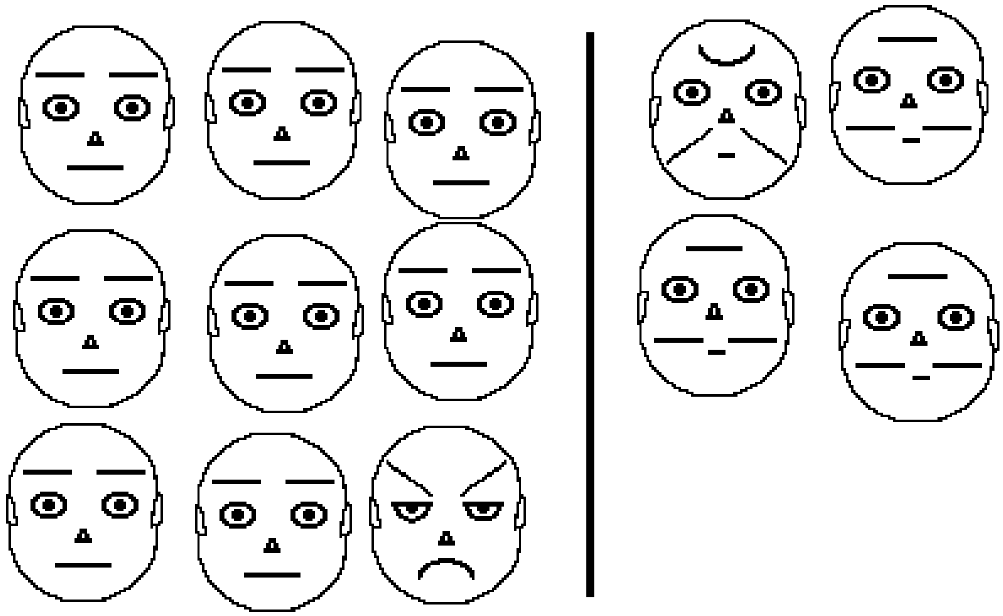

Figure 3. **Two examples of the stimulus arrays as used in Experiments 2, and 3. Shown is the typical trial to trial random jitter. On the left is a nine item display showing Öhman-Feature stimuli. On the right is a typical Affect-Neutral four item display as used in Experiment 3. Note that when four items are presented the distrators have the same proximity to the target as distractors in nine item displays.**

Apparatus and Stimuli. All stimuli were presented via a computer using Vscope software (Enns, Ochs & Rensink, 1990; Ennis & Rensink, 1991). Observers were positioned against one end of a table so that their eyes were approximately 60 cm from the monitor (no head restraint was used). An individual face stimulus subtended approximately 2.77 degs in width by 3.15 degs in height. The entire nine-face array subtended 9.24 degs by 10.76 degs and was centered on a 0.92 by 0.92 deg fixation cross. Within the array the center of each face was separated from its neighbor 2.74 degs horizontally and 3.04 degs vertically except that the exact position of an individual face within the three-by-three array was spatially jittered up to 0.22 deg across trials. A single target face occurred randomly in one of the nine possible positions. The remaining eight locations were occupied by neutral faces.[1] Examples of the spatial arrangement of stimuli can be seen in Figure 3.

Procedure. A Go/No-Go procedure was used. Observers pressed the “0” key of a numeric key pad if the array contained a face different from the crowd of neutral faces. They refrained from responding if all the faces in the array were neutral. Observers knew that target-present and target-absent occurred at random. They also knew that the target would be at one of the nine possible locations and that its position shifted randomly with each trial. Observers we told that their best performance could be achieved by focusing on the fixation cross as they initiated each trial. They were told not to anticipate the type of trial (target-present or target-absent) or where the target face might appear.

The stimulus crowds were previewed on the display monitor prior to practice and data collection. In common with other experiments we did not describe the faces or refer to them as happy, angry or neutral (Hansen & Hansen, 1988; Hampton et al., 1989; Gilboa-Schechtman et al., 1999; Öhman, 2001).

Trials were run in five blocks of 36 trials each. The first block was practice and response times are not included in the data. Observers were not told of the proportion of target (to non-target trials (60 percent present to 40 percent absent). Observers were prompted by the computer to initiate a trial. A central fixation cross appeared for 705 ms. Its offset was followed by a white screen for 300 ms, followed by an array of faces. If the array contained a target face, and the observer responded, the array offset and the response time was recorded. If the observer failed to respond the array offset after 825 ms. If the crowd display did not contain a target the stimulus array offset after 825 ms. The offset of the array was followed by a 855 ms white screen, at which time the observer was cued to begin another trial. Observers were allowed to rest between blocks. Practice and data collection took about 20 minutes.

Results

The mean response times at each location in the stimulus array are shown for Affect-Neutral (left panel) and Öhman-Feature faces (right panel) in Figure 4. There is no systematic difference between Öhman-Feature faces and Neutral-Feature/Affect-Neutral target faces. There is a clear indication of a pseudo ASE. The nonconforming stimuli (pseudo-angry and angry) are responded to more quickly than the conforming stimuli (pseudo-happy and happy). For almost all stimuli response times are longest for targets at the first and third positions of a row, where acuity is poorest.

Feature-Organization (Öhman-Feature vs Affect-Neutral) was treated as between-subjects variable. Feature-Conformation nonconforming (pseudo-angry and angry) vs conforming (pseudo-happy and happy), and position were within-subject variables. Individual response times were normalized by taking their common logarithm. Studentized Scores with residuals whose absolute value was greater than four were dropped from the analysis. The interaction of Feature-Conformation (conforming or nonconforming) with retinal position is a critical test of our prediction that a pseudo ASE is strongest with stimuli presented furthest from the fovea.

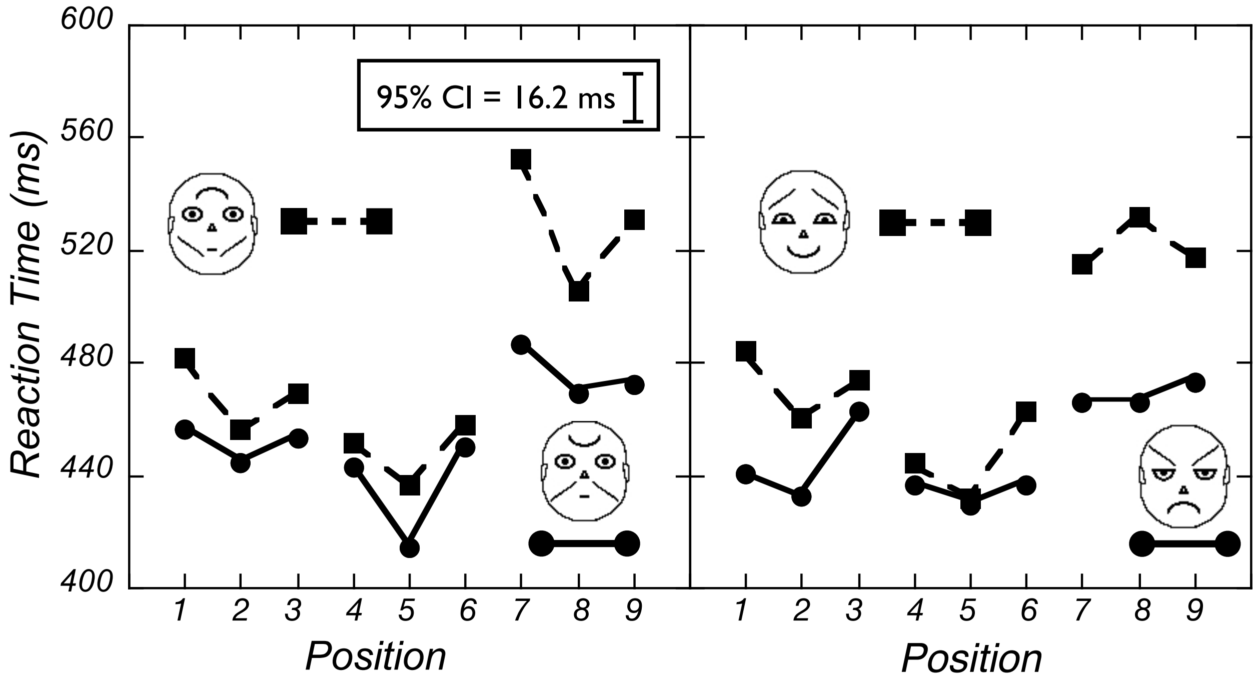

***Figure 4*. Experiment 2 data from Affect-Neutral features (left panel) and from normal Öhman-Feature faces (right panel) for Conforming/Happy features and for Nonconforming/Angry features. Positions 1, 2 and 3 are the top row, 4, 5 and 6 are the middle row and 7, 8 and 9 are the bottom row. Targets are shown. The 95% confidence interval is based on the *MSE* for Feature-Conformation.**

Error rates are low in all experiments (p > .5) for the Affect-Neutral stimuli of Experiment 2 the conforming/happy features gave 98.9 percent correct and the nonconforming/ angry features gave 98.5 percent correct (p = .67) stimuli. For the Öhman-Feature faces of Experiment 2 the conforming/happy features and the nonconforming/angry features gave respectively 98.8 and 99.4 percent correct (p = .25).

The variable of Feature-Organization (Öhman-Feature faces vs Affect-Neutral faces) is not statistically significant with $F(1,30) = .0394$, $p = .84$, $MSE = 0.0412$, $\eta_p^2 = .001$, but as expected the main effect of Feature-Conformation (angry/nonconforming vs happy/conforming) is stastically significant , $F(1,30) = 57.143$, $p \leq .0001$, $MSE = 0.00183$, $\eta_p^2 = .66$, with faster search times for angry/nonconforming targets. Most important for our hypothesis is the finding that Feature-Organization does not interact with Feature-Confirmation (angry/nonconforming vs happy/conforming), $F(1,30) = 0.17$, $p = .69$, $MSE = 0.0018$, $\eta_p^2 = .006$. This interaction must be statistically significant if judged affect predicts the ASE/Pseudo-ASE (Öhman et al., 2001; Lundqvist and Öhman, 2005). This is not the case. Our Affect-Neutral stimuli produce as large an ASE/pseudo-ASE as do Öhman stimuli. Experiments 1A and 1B find small differences (0.8 units) in affect ratings between our Affect-Neutral conforming and nonconforming stimuli, while that difference for Öhman nonconformiing/angry and conforming/happy stimuli is large (6.5 units) This contrast between affect ratings and the size of the ASE/pseudo-ASE provides a clear dissociation between how angry a face is rated and the reaction time data, just as our hypothesis requires.

Feature-Organization does not interact with any other variable, an additional indication that Affect-Neutral and Öhman stimuli are similar in their effect. The first-order interaction of Feature-Organization × Position gives $F(8,240) = 0.91$, $p = .51$, $MSE = 0.001807$, $\eta_p^2 = .03$ and the second-order interaction of Feature-Organization × Feature-Conformation × Position gives $F(8,240) = 0.86$, $p = .55$, $MSE = 0.0012$, $\eta_p^2 =.03$. Our Affect-Neutral stimuli produce results which are not differenct from those produced by Öhman feature faces.

The magnitude of the ASE/pseudo-ASE differs as a function of retinal position. The main effect of Position $F(8,240) = 21.53$, $p \leq .0001$, $MSE = 0.001807$, $\eta_p^2 = .42$ is statistically significant, and as predicted, so is the first-order interaction of Feature-Conformation × Position, $F(8,240) = 3.61$, $p \leq .0006$, $MSE = 0.0012$, $\eta_p^2 = .11$. While not predicted by affect ratings this interaction is consistent with the fact that the angry/nonconforming facial features are less influenced by position than are the conforming facial features (Figure 4).

Experiment 3: Four versus Nine stimuli

In Experiment 2 we only used nine-item displays. In Experiment 3 we compare search with four-item displays to search with nine-item displays. The faces were identical with those of Experiment 2 although individual faces were seperated from each other by a slightly larger space, and while Experiment 2 used 60 percent target present trials Expeirment 3 used 50 percent target present trials.

Method

Participants. Sixty undergraduate students volunteered to serve as observers as part of their introductory psychology course. Participants provided informed consent as required by the Institutional Review Board of Oakland University. Thiry-one observers were used in the Affect-Neutral condition of Experiment 3. An additional 29 observers were used in the Öhman-Feature condition of Experiment 3. One observer was dropped from the Öhman-Feature condition because of false-alarms greater than 10 percent.

Apparatus and Stimuli. All stimuli were presented via a computer using Vscope software (Enns, Ochs & Rensink, 1990; Enns & Rensink, 1991). Observers were positioned against one end of a table so that their eyes were approximately 60 cm from the monitor (no head restraint was used). An individual face stimulus subtended approximately 3.1 degs in width by 3.34 degs in height. The entire nine-face array subtended 12.46 degs wide by 12.55 degs high and was centered on a 0.92 by 0.92 deg fixation cross. Within the array the center of each face was separated from its neighbor 4.7 degs horizontally and 4.6 degs vertically except that the exact position of an individual face within three-by-three array was spatially jittered up to 0.22

deg across trials. The spatial arrangement of Nine face arrays resembled that shown on the left side of Figure 3. Four item displays resembled that shown on the right side of Figure 3.[2]

Procedure. Experiment 3 used the same Go/No-Go procedure as Experiment 2. Trials were run in four blocks of 72 trials each. This allowed for 4 trials per the 36 experiment conditions. Prior to data collection two practice blocks of 15 trials each were run. Observers were not told of the proportion of target (50 percent) to non-target trials (50 percent). The trial sequence and timing is the same as in Experiment 2. Targets occured pseudo randomly an equal number of times in each of the nine positions within the face array. Distractors clustered as closely around the target in four item arrays as in nine item arrays (Figure 3).

Results

Error rates are very low in both Öhman and Affect-Neutral stimuli. For the Affect-Neutral stimuli of Experiment 3 the conforming/happy features are correctly reported on 97.94 percent of the trials while the nonconforming/angry features were reported correctly 98.25 percent of the time (p = .43). The Öhman featured faces of Experiment 3 gave 98.61 percent for the conforming/happy features and 98.96 percent for the nonconforming/angry features (p = .41).

As in Experiment 2 the main effect of Feature-Conformation (Angry/Nonconforming vs Happy/Conforming) $F(1,57) = 198.27$, $p \leq .0001$, $MSE = 0.002$, $\eta_p^2 = .78$ is statistically significant, showing that stimuli that conform to the facial surround take longer to respond to than do stimuli that do not conform to the facial surround. The effect of *Feature-Organization* (Öhman faces vs Affect-Neutral faces) leaned toward statistical signifiance with Öhman faces taking less time to respond to than Affect-Neutral faces $F(1,57) = 2.51$, $p = .12$, $MSE = 0.034$, $\eta_p^2 = .042$. If, as Öhman et al. (2001) argue, affect ratings predict the magnitude of the ASE/psuedo-

ASE there should be a strong interaction of Feature-Conformation with Feature-Organization with a much larger effect for the Öhman stimuli than for our Affect-Neutral stimuli. This is not supported by the data as the interaction of Feature-Conformation × Feature-Organization F (8,456) = 1.55, p = .14, MSE = 0.0014, η_p^2 = .026 only leaned toward statistical significance. The ASE/pseudo-ASE is 36.5 ms for the Öhman faces and 31.5 ms for the Affect-Neutral faces. If judged affect determined reaction time then the interaction of Feature-Conformation × Feature-Organization would have been significant with large differences between conforming and nonconforming faces for the Öhman feature condition but with little difference for the Affect-Neutral faces.

The statistically significant main effect of Position F(8,456) = 59.98, $p \leq .0001$, MSE = 0.002, η_p^2 = .51 must be interpreted in light of the Feature-Conformation × Position interaction F(8,456) = 7.12, $p \leq .0001$, MSE = 0.0014, η_p^2 = .11 (Figure 5). This interaction demonstrates that the conforming/happy stimuli are more difficult to locate than are nonconforming/angry when they are located farther and farther away from the fixation point, just as in Experiment 2. Although consistant with our feature-surround interaction hypothesis this interaction is contrary to the Öhman affective activation hypothesis (Öhman et al., 2001, p. 393). The effect of position is constant across Öhman and Affect-Neutral faces as the Feature Organization × Position interaction only leaned toward statistical significance F(8,456) = 1.66, p = .11, MSE = 0.002, η_p^2 = .028. The Feature-Organization × Feature-Conformation × Position F(8,456) = 1.55, p = .14, MSE = 0.00136, η_p^2 = .026 show a similar trend.

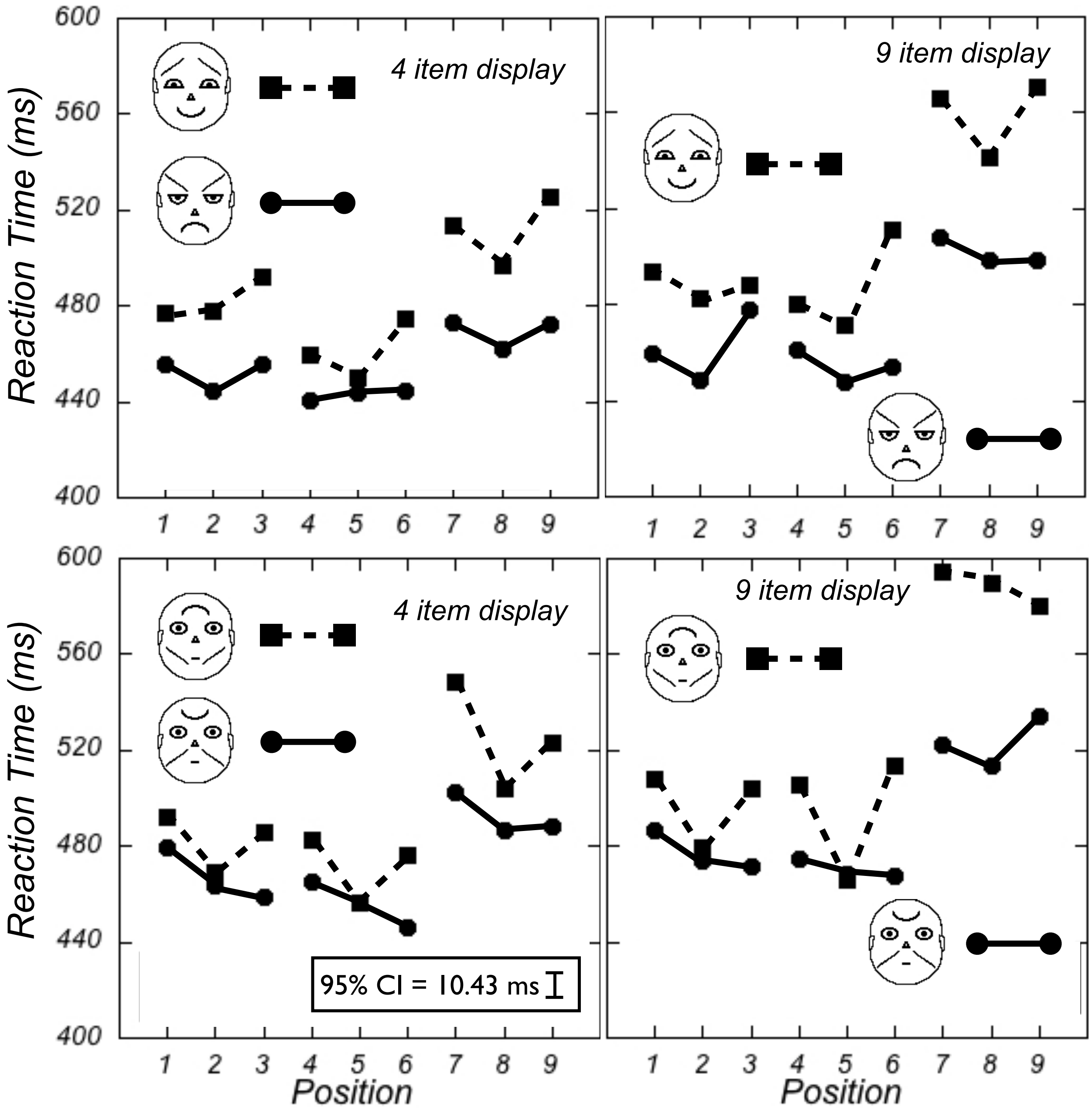

Figure 5. **Data from the conforming/happy features and nonconforming/angry features of Experiment 3.The top panels displays data for Öhman faces and the bottom panels display data for our Affect-Neutral features. Positions 1, 2 and 3 comprise the top row of the display, positions 4, 5 and 6 comprise the middle row and positions 7, 8 and 9 comprise the bottom row. The 95% confidence interval is based on the *MSE* for Feature-Conformation.**

Number of Stimuli (4 vs 9) is statistically significant $F(1,57) = 161.52$, $p \leq .0001$, $MSE = 0.0014$, $\eta_p^2 = .74$, with faster response times when targets are presented with three distracters rather than eight (Figure 8). The first-order interaction of Number-of-Stimuli × Feature-Conformation is statistically significant, $F(1,57) = 8.2$, $p = .006$, $MSE = 0.0012$, $\eta_p^2 = .126$. This interaction results from the faster search rates with nonconforming/angry stimuli (3.6 ms/item) than with conforming/happy stimuli (5.8 ms/item). These rates are consistent with efficient search for both target types. The slightly slower search for conforming targets may be due to the greater difficulty in determining their presence at some retinal positions (Figure 8). The interaction of Number-of-Stimuli × Position is also statistically significant, $F(8,456) = 7.5$, $p \leq .0001$, $MSE = 0.0012$, $\eta_p^2 = .116$. This interaction reflects the larger response time advantage for four-item displays as compared to nine-item displays in the bottom row of the display. The average difference between four- and nine-item displays is 45.37 ms in the bottom row of the display (positions 7, 8 and 9) while this difference averges only 15 ms for the other six positions (Figure 5).

None of the other interactions involving Number of Stimuli is statistically significant. The first-order interaction of Feature-Organization (Öhman faces vs Affect-Neutral) × Number of Stimuli gave $F(1,57) = 0.65$, $p = .42$, $MSE = 0.0014$, $\eta_p^2 = .011$. The Feature Organization × Feature Conformation × Number of Stimuli gave $F(1,57) = 0.77$, $p = .38$, $MSE = 0.0012$, $\eta_p^2 = .013$ and the Feature Organization × Position × Number of Stimuli gave $F(8,456) = 0.68$, $p = .71$, $MSE = 0.0012$, $\eta_p^2 = .012$. The Feature-Conformation × Position × Number of Stimuli gave $F(8,456) = 1.31$, $p = .24$, $MSE = 0.00146$, $\eta_p^2 = .022$. The third order interaction of Feature-Organization × Feature-Conformation × Position × Number of Stimuli is not statistically significant $F(8,456) = 1.22$, $p = .29$, $MSE = 0.0011$, $\eta_p^2 = .021$.

In Experiments 2 and 3 the ASE/Pseudo ASE found with Öhman-Feature faces is statistically indistinguishable from that with our Affect-Neutral faces. Tipples et al. (2002) pointed out that the V-shaped eyebrow frown enhances the detectability of an angry face relative to the inverted V-shaped eyebrow of the happy face. Larson, Aronoff and Stearns (2007) make a similar argument. However V-shaped eyebow features produce opposit results when contained within our Affect-Neutral faces. The same enhanced detectability is obtained when the V is inverted (Nonconforming), even though inversion makes it difficult to judge a faces emotion. We find that the nonconforming eyebrow featue enhances detectability regardless of whether it is upright and V-shaped at the top of the Öhman feature face or an inverted V at the bottom of our Affect-Neutral stimuli. What is common to the two conditions, and what yields their faster detectability, are features that do not conform to their surrounds. Affect is largely irrelevant.[3]

Experiment 4: **Normal and inverted surround-absent features**

There is a still more direct test for the presence of a pseudo-ASE. Remove the face's ovoid surround. The pseudo-ASE should disappear once the ovoid surround is removed, and why it disappears is an essential part of our narrative. Because the features of a happy face are no longer incorporated within the ovoid surround the features of a happy face will be as legible as those of an angry face and therefor a happy face will be located just as quickly as an angry face. Removing the facial surround will also diminish the effect of retinal position. With facial features no longer malformed by a facial surround the position of a target face within an array becomes less important. Because removing the facial surround leaves affect ratings unchanged Öhman features without surrounds should, if Öhman et al. (2001) are correct, produce a strong ASE.

Method

Participants. Sixty-nine students volunteered to serve in the experiment as partial fulfillment of the requirements for introductory psychology courses. Thirty-six subjects served in the right side up condition and 33 served in the upside down condition. One subject was dropped from the right side up condition and 2 were dropped from the upside down condition due to errors greater than 10 percent. Participants provided informed consent as required by the Institutional Review Board of Oakland University.

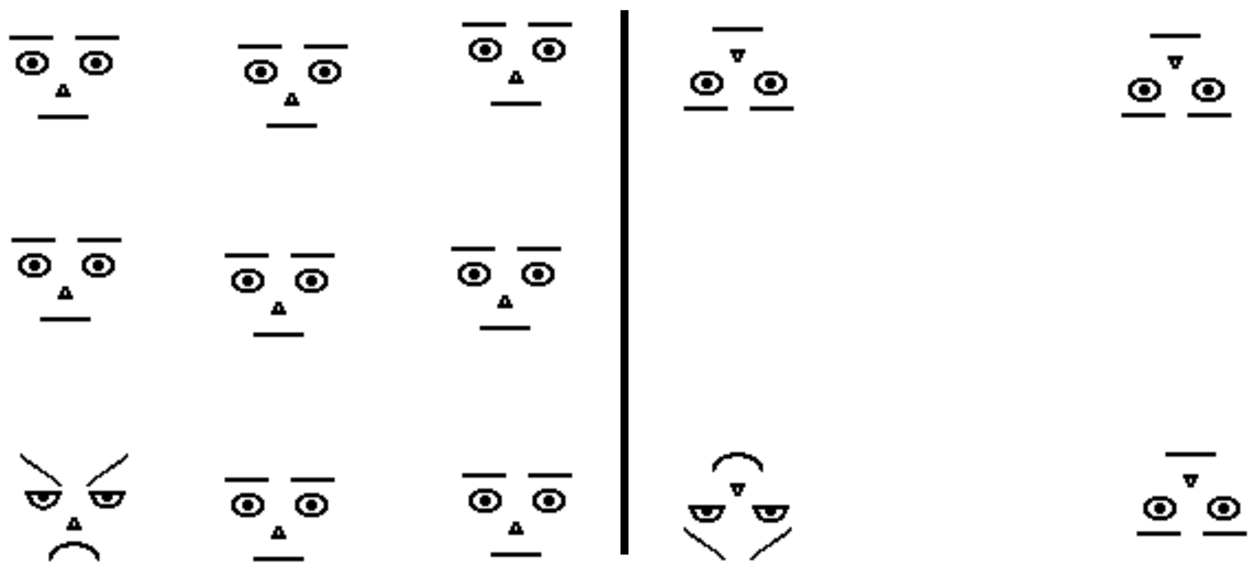

Figure 6. **Examples of the stimuli used in Experiment 4. On the left is a nine item display with an angry target. On the right is the X configuration of an upside down four item display with a happy target. Not shown is the + configuration of a four item display.**

Apparatus and Procedure. The apparatus and procedures were identical to those of Experiment 3 with three exceptions. The stimuli were the normal Öhman-feature stimuli with the facial surround removed. In one condition normal upright versions were used and in the other inverted versions were used (Figure 6). Nine-item displays were spaced as in Experiment 3.

However, four-item displays differed from those of Experiment 3. For half of the four-item displays targets and distractors were presented in a + configuration at compass points of 0, 90, 180 and 270 deg. For the other half they were placed in an X configuration at 45, 135, 225 and 315 deg (Figure. 6). Item separation in the 4 item displays insured that individual features will be seen as part of a coherent face and not as a jumble of unattached features as might occur for the more closely spaced items in the nine-item display.[4] With this spatial arrangement for the four-item displays no target or distractor was presented at fixation. Only a distractor is presented at fixation in the nine-item displays.

Results

Stimulus orientation is a between-observer variable while all other variables are within-observer. Error rates are low. For the right side up stimuli of Experiment 4 the conforming/happy features gave 98.51 percent correct and the nonconforming/angry features gave 98.62 percent correct response (p = .78). For the inverted featured faces of Experiment 4 error rates are also low. The conforming/happy features and the nonconforming/angry features gave respectively 98.66 and 99.16 percent correct response (p = .26).

Analysis of response times and the ASE/Pseudo-ASE reveal important differences from Experiments 2 and 3. Orientation (normal vs upside down) is not statistically significant $F(1,64) = 1.46$, $p = .23$, $MSE = 0.064$, $\eta_p^2 = .022$, although Orientation interacts with other variables. As with Experiments 1 and 2 the main effect of Feature-Conformation $F(1,64) = 73.102$, $p \leq .0001$, $MSE = 0.001199$, $\eta_p^2 = .53$ demonstrates a statistically significant ASE/Pseudo-ASE. We predicted that the ASE would disappear with elimination of the facial surround. While that did not happen, removing the surround reduced the magnitude of the ASE by improving performance on the happy/conforming features (Figures 4, 5 and 7) just as we predicted. With angry/ nonconforming features surround removal produced a smaller improvement. Averaged across the surround present conditions of Experiments 2 and 3 there is a 31.5 ms ASE/Pseudo-ASE. Removing the facial surround decreased this to 17.76 ms. Inverting the surround-absent faces decreased the ASE/pseudo-ASE by an additional 9.64 ms to 8.12 ms. The fact that the ASE/ pseudo-ASE is 9.64 ms smaller for upside down faces is supported by the Feature-Conformation × Orientation interaction $F(1,64) = 9.105$, $p = .0037$, $MSE = 0.077$, $\eta_p^2 = .13$ and reinforces our work with surround-absent features modeled after those of Fox (Fox et al., 2000; Purcell & Stewart, 2006). As with the affect of Feature-Conformation, removing the surround also reduces the effect of Position, $F(7,448) = 11.58$, $p \leq .0001$, $MSE = 0.00129$, $\eta_p^2 = .153$, and eliminates the Feature-Conformation × Position interaction $F(7,448) = 0.79$, $p = .59$, $MSE = 0.001$, $\eta_p^2 = .012$ (Figure 7).[5] These effects related to retinal position also support our feature-surround interference hypothesis. Interference from the surround is stronger farther away from fixation. Removing the surround eliminates this source of interference and makes stimuli more uniformly legible across retinal position. The Orientation × Position interaction is statistically Significant $F(7,448) = 3.32$, $p = .002$, $MSE = 0.0012$, $\eta_p^2 = .049$ with smaller effects of position for inverted stimuli.

Unlike Experiments 2 and 3 Number of Stimuli, $F(1,64) = 1.075$, $p = .30$, $MSE = 0.0014$, $\eta_p^2 = .017$, is not statistically significant and search slopes are nearly flat (Figure 8). The first-order interaction of Orientation × Number of Stimuli is not significant, $F(1,64) = 0.034$, $p = .86$, $MSE = 0.0014$, $\eta_p^2 = .001$, nor is the first-order interaction of Feature-Conformation × Number of Stimuli $F(1,64) = 0.086$, $p = .77$, $MSE = 0.0009$, $\eta_p^2 = .001$; the first-order interaction of

Number of Stimuli × Position leans toward statistical significance $F(7,448) = 1.93$, p = .06, $MSE = 0.0009$, $\eta_p^2 = .029$. These nonsignificant first-order interactions must be qualified by the statistically significant second-order interaction of Feature-Conformation × Number of Stimuli × Position $F(7,448) = 2.14$, p = .038, $MSE = 0.0009$, $\eta_p^2 = .032$. This interaction appears to be due to the ASE/Peudo-ASE being relatively constant for six of the eight positions tested. However this is not so for positions 2 and 8. Position 2 showed a 17 ms larger ASE for four-item displays than for nine-item displays while position 8 showed the opposite pattern with a 15 ms larger ASE for the nine-item display. The second-order interactions of Orientation × Feature-Conformation × Number of Stimuli $F(1,64) = 0.77$, p = .38, $MSE = 0.0009$, $\eta_p^2 = .012$ and Orientation × Feature-Conformation × Position $F(7,448) = 0.80$, p = .59, $MSE = 0.001$, $\eta_p^2 = .012$ are not statistically significant. The third-order interactions of Orientation × Number of Stimuli × Position $F(7,448) = 0.73$, p = .65, $MSE = 0.0009$, $\eta_p^2 = .011$ and Orientation × Feature-Conformation × Number of Stimuli × Position $F(7,448) = 1.28$, p = .256, $MSE = 0.0009$, $\eta_p^2 = .02$ are not statistically significant.

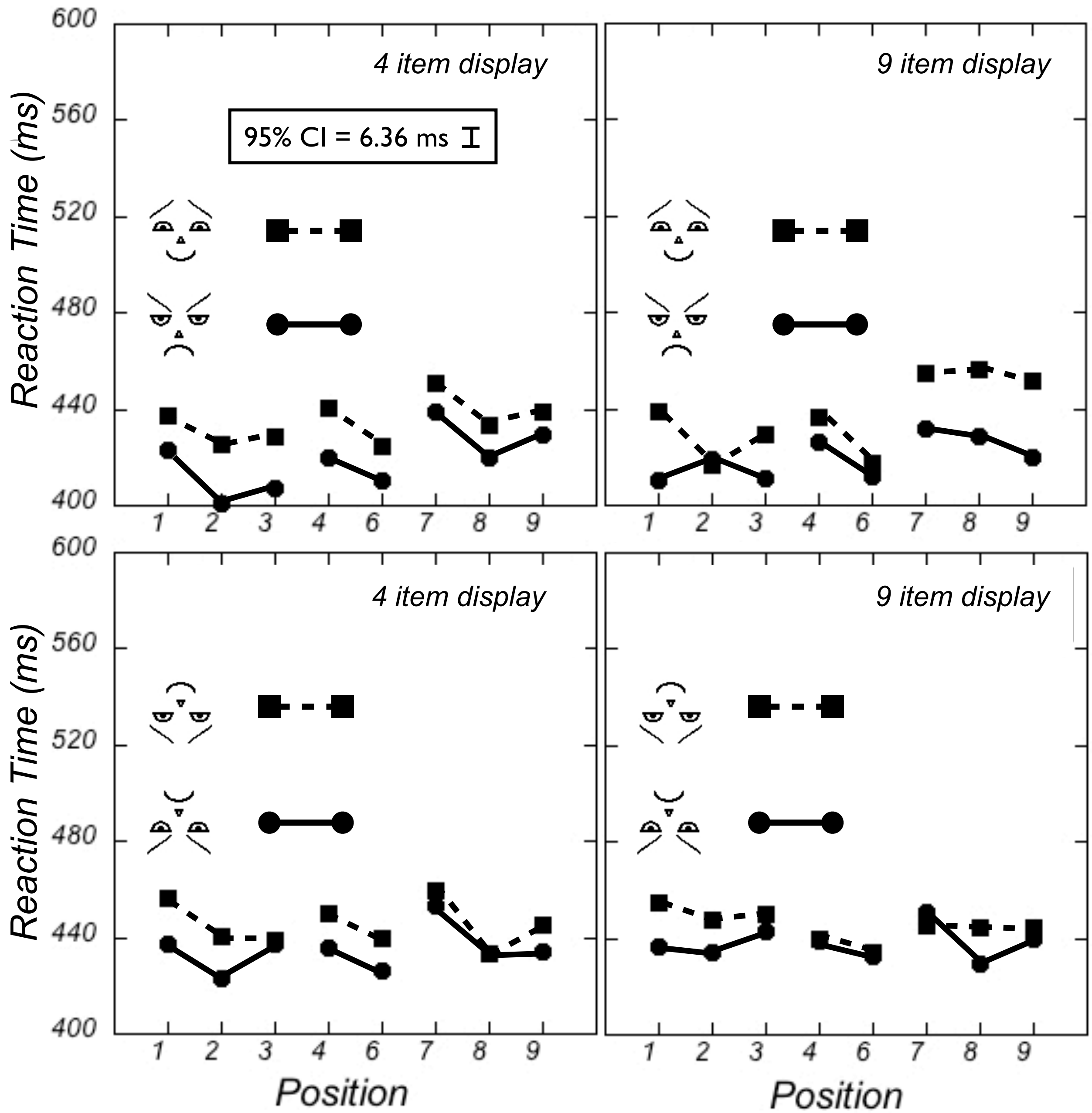

Figure 7. **Data from the normal and inverted features of Experiment 4 are shown. Data from normal faces are in the top two panels and that from inverted faces are in the bottom two panels. Data from four item displays are on the left and that from nine item displays are on the right. Positions 1, 2 and 3 are the top row, 4 and 6 are the middle row and 7, 8 and 9 are the bottom row. The 95% confidence interval is based on the *MSE* for Feature-Conformation.**

Discussion

The results of Experiment 4 differed from those of Experiments 2 and 3 in three important ways. Without a surround the anger-superiority effect is greatly reduced, even though Experiment 1 shows that the surround-absent features themselves are rated just as angry and happy as faces with surrounds. Important for our hypothesis, removing the surround yields a greater improvement in performance for the conforming/happy features than for the nonconforming/angry features. As can be seen by comparing Figures 4 and 5 to Figure 7 the effect of Feature-Conformation is reduced as is the effect of Position, and there is no longer an interaction between Feature-Conformation and Position. In other words the magnitude of the surround-absent ASE/Pseudo ASE is no longer dependent on target position as it is for faces with surrounds.

When the facial surround is absent there is a smaller ASE (17.76 ms) than that found when the surround is present (31.5 ms). To determine the extent to which this reduced ASE is due to non-affect related factors we inverted the surround-absent stimuli. Should face inversion have no effect on the magnitude of the ASE we would have concluded that the surround-absent ASE is just due to low-level features. However, the low-level feature effects of the inverted faces produce a smaller ASE/pseudo-ASE (8.12 ms). The difference between this and the ASE/psuedo-ASE found with right side up features suggests the possibility of a 9.64 ms true ASE with surround-absent faces. Our advice is that investigations of the schematic face ASE use surround-absent features coupled with an up side down control to assess the contribution of non emotional factors to the effect.

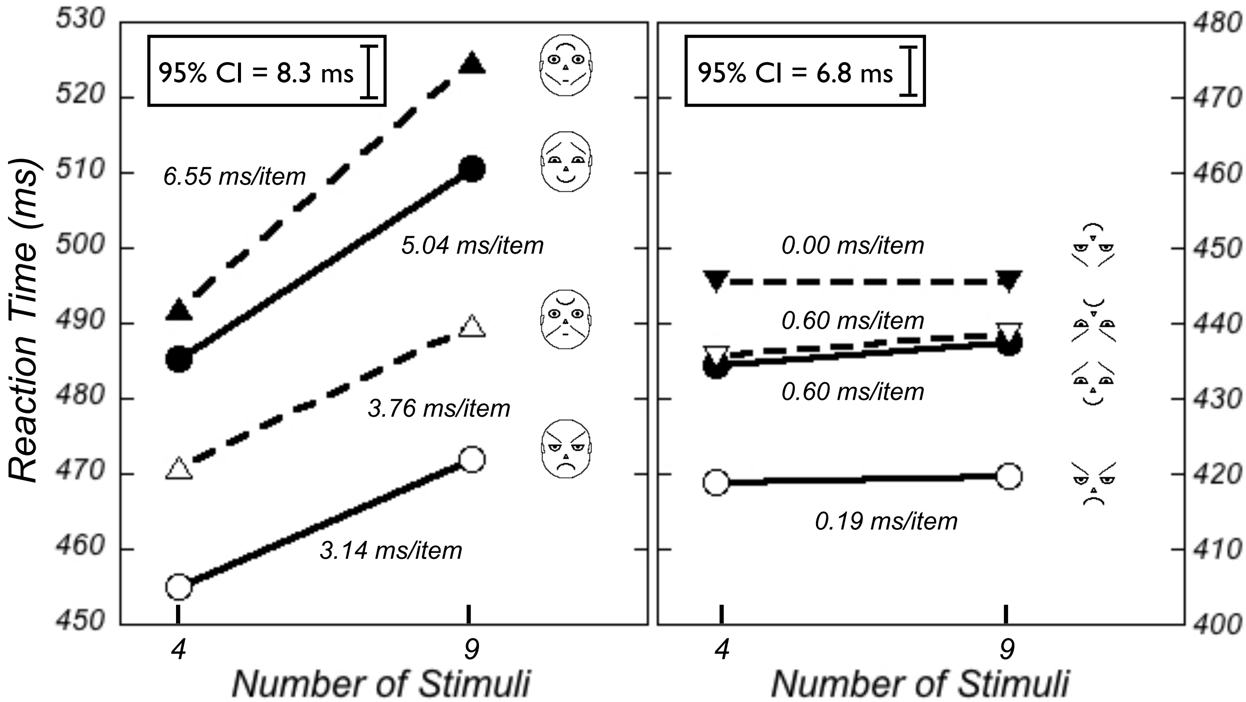

Figure 8. **Average slopes for Experiment 3 (left panel) and for Experiment 4 (right panel). To facilitate comparison between experiments each panel has a reaction time range of 80 ms. Note that the slowest surround-absent reaction times are faster than the fastest surround present reaction times. The 95 % confidence intervals are based on the *MSE* for Number of Stimuli.**

General Discussion

Öhman et al. (2001) argue that the more angry a face is rated the faster an observer will response to that face when it is used in a visual search task. Schematic faces rated 6.53 units more angry than happy faces did produce an average ASE of 33 ms in our Experiments 2 and 3. However, our Affect-Neutral stimuli with nonconforming features were rated only slightly more angry than the conforming stimuli (Exp 1A, 5.8 vs 5.0; Exp 1B, 6.26 vs 5.39). These stimuli still produced a pseudo-ASE of 29 ms, a result that is 4 ms smaller and not statistically different from that produced with Öhman stimuli. An experiment using many more observers could find that this residual 4 ms difference is statistically significant. Nonetheless, such a circumspect interpretation of the data does not alter the fact that eliminating the feature-surround interaction results in statistically significant faster responses for stimuli with conforming/happy features.

There are also other anomalies that are troublesome for experiments on emotion and visual search. Variation in the size of the ASE/pseudo-ASE with retinal position is not predicted by affect ratings. Nor do affect ratings predict the reduction in the size of the pseudo-ASE that occurs when stimuli are presented without a facial surround. Even with large differences in affect ratings (6.26 units) the surround-absent stimuli produce an ASE/pseudo-ASE which we estimate at only 9.64 ms, and the effect across retinal position is much smaller than with Öhman stimuli. Whatever a person's view of the ASE effect, the Öhman stimuli are fraught with the kind of low-level visual artifacts they were meant to avoid, leaving the existence of an ASE an open question. It could still be argued that there is an ASE with surround-present Ohman stimuli, but the evidence is ambiguous. If the results are due to an ASE, it is curious that a similar ASE is produced with our almost affect-neutral stimuli.

Even the origin of the ASE and pseudo-ASE remains an open question. The ASE is often seen as the result of evolutionarily selected means of rapidly detecting a threatening individual (Fox et al., 2000; Eastwood, Smilek & Merikle, 2001; Öhman et al., 2001). There are equally plausible alternative explanations, however. The schematic face effect may to be due to low-level features that are unrelated to facial affect but that give an advantage to angry features (Calvo & Nummenmaa, 2008; Coelho et al., 2010). Alternatively, as we propose, the effect can be due to low-level features that give an absolute disadvantage to the happy face (Purcell & Stewart, 2005; 2006). All the non-affect, low-level feature models for the pseudo-ASE provide that a facial surround is necessary to obtain the effect. Two of the non-affect models postulate that a pseudo-

ASE is due to an absolute advantage for angry features that comes about because of an interaction between the outwardly pointing eyebrow and mouth features with the facial surround (Calvo & Nummenmaa, 2008; Coelho et al., 2010). Calvo and Nummenmaa argue that the facial surround renders the angry features as more distinctive relative to happy and neutral features. Coelho et al. (2010) demonstrate with simple geometric shapes that the surround interacts with the outward pointing eyebrows and mouths of an angry face to yield easily detected T-junctions. Our alternative explanation is that the ASE/pseudo-ASE is the result of a destructive interaction between the facial surround and conforming/happy features. This destructive action makes it more difficult to identify a happy face. None of these low-level feature explanations require assumptions about rapid processing of facial affect.

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Footnotes

[1] To compensate for retinal position, stimuli above and below fixation would have to be increased in size by a factor of 2.47. Stimuli directly left and right of fixation would have to be increased in size by a factor of 2.26, while stimuli on the corners of the display would have to be increased by a factor of 3.48.

[2] To compensate for retinal position, stimuli above and below fixation would have to be increased in size by a factor of 2.71. Stimuli directly left and right of fixation would have to be increased in size by a factor of 2.7, while stimuli on the corners of the display would have to be increased by a factor of 3.83.

[3] Our findings suggest that the use of schematic faces to investigate face perception of people with affect disorders may greatly over estimate the magnitude of the ASE for those individuals (e.g. Ashwin, Wheelwright, & Baron-Cohen, 2006; Hahn, Carlson, Singer, & Gronlund, 2006; Mather & Knight, 2006; Ruffman, Ng, & Jenkin, 2009; Waters & Lipp, 2008).

[4] This was done because of concerns of an anonymous reviewer that surround-absent faces might appear as a jumble of features.

[5] While we find a reduced effect of feature conformation when surrounds are removed Schubö et al. (2006) report no effect of feature conformation when surrounds are removed.

Figure Captions

Figure 1. In Experiment 1 these faces were rated for the degree to which they represent happyness or anger.

Figure 2. Shown are rating scores and 95% confidence intervals from Experiments 1A and 1B. These ratings are for the target stimuli (Conforming/happy, Nonconforming/angry) and the crowd stimuli (Neutral) of Experiments 2 & 3 (Affect-Neutral and Normal), and stimuli (Surround-Absent Faces) of Experiment 4. The 95% confidence interval is based on the MSE for Feature-Conformation.

Figure 3. Two examples of the stimulus arrays as used in Experiments 2, and 3. Shown is the typical trial to trial random jitter. On the left is a nine item display showing Öhman-Feature stimuli. On the right is a typical Affect-Neutral four item display as used in Experiment 3. Note that when four items are presented the distrators have the same proximity to the target as distractors in nine item displays.

Figure 4. Experiment 2 data from Affect-Neutral features (left panel) and from normal Öhman-Feature faces (right panel) for Conforming/Happy features and for Nonconforming/Angry features. Positions 1, 2 and 3 are the top row, 4, 5 and 6 are the middle row and 7, 8 and 9 are the bottom row. Targets are shown. The 95% confidence interval is based on the MSE for Feature-Conformation.

Figure 5. Data from the conforming/happy features and nonconforming/angry features of Experiment 3.The top panels displays data for Öhman faces and the bottom panels display data for our Affect-Neutral features. Positions 1, 2 and 3 comprise the top row of the display, positions 4, 5 and 6 comprise the middle row and positions 7, 8 and 9 comprise the bottom row. The 95% confidence interval is based on the MSE for Feature-Conformation.

Figure 6. Examples of the stimuli used in Experiment 4. On the left is a nine item display with an angry target. On the right is the X configuration of an upside down four item display with a happy target. Not shown is the + configuration of a four item display.

Figure 7. Data from the normal and inverted features of Experiment 4 are shown. Data from normal faces are in the top two panels and that from inverted faces are in the bottom two panels. Data from four item displays are on the left and that from nine item displays are on the right. Positions 1, 2 and 3 are the top row, 4 and 6 are the middle row and 7, 8 and 9 are the bottom row. The 95% confidence interval is based on the MSE for Feature-Conformation.

Figure 8. Average slopes for Experiment 3 (left panel) and for Experiment 4 (right panel). To facilitate comparison between experiments each panel has a reaction time range of 80 ms. Note that the slowest surround-absent reaction times are faster than the fastest surround present reaction times. The 95 % confidence intervals are based on the *MSE* for Number of Stimuli.

Figure 1

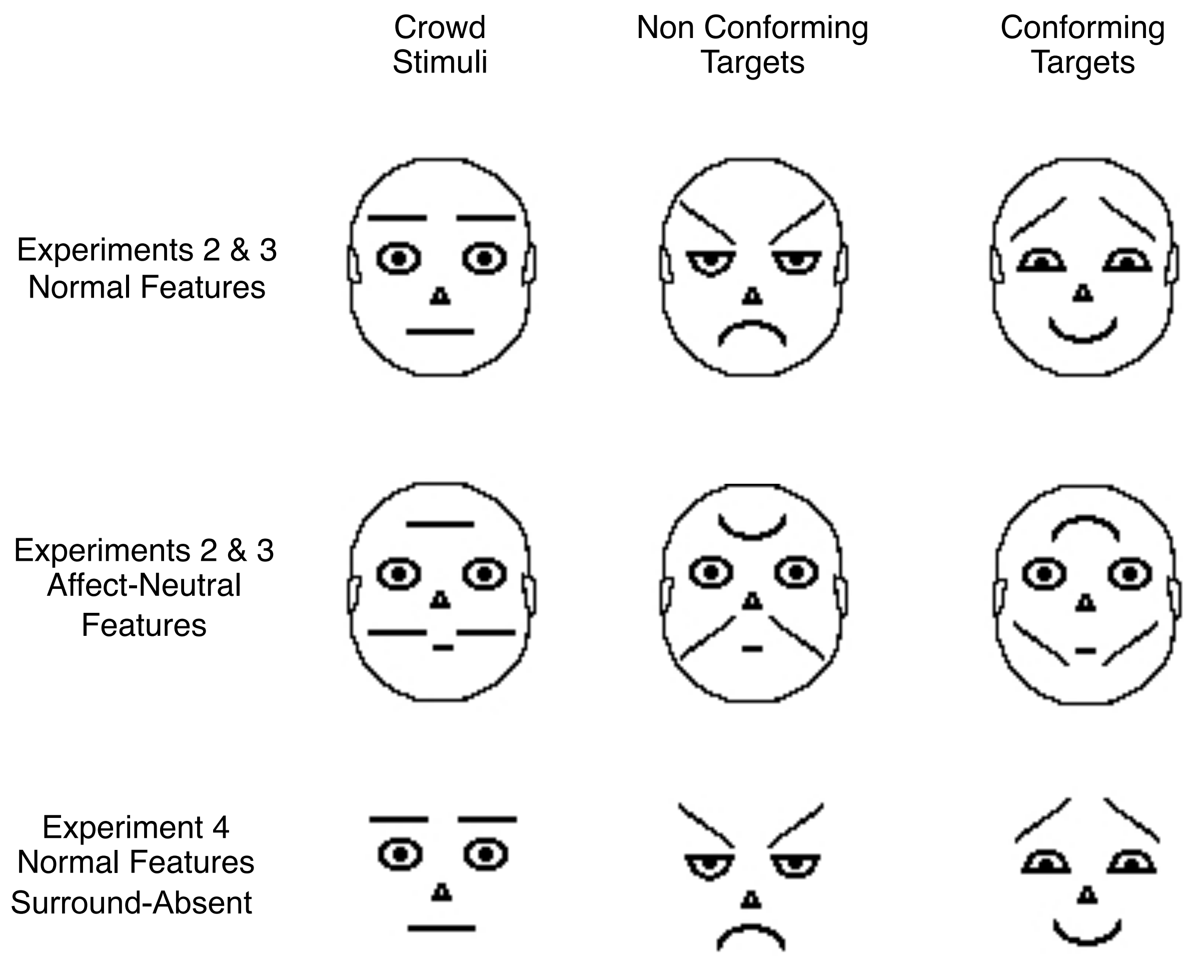

Crowd
Stimuli
Non Conforming
Targets
Conforming
Targets
Experiments 2 & 3
Normal Features
Experiments 2 & 3
Affect-Neutral
Features
Experiment 4
Normal Features
Surround-Absent

Figure 2

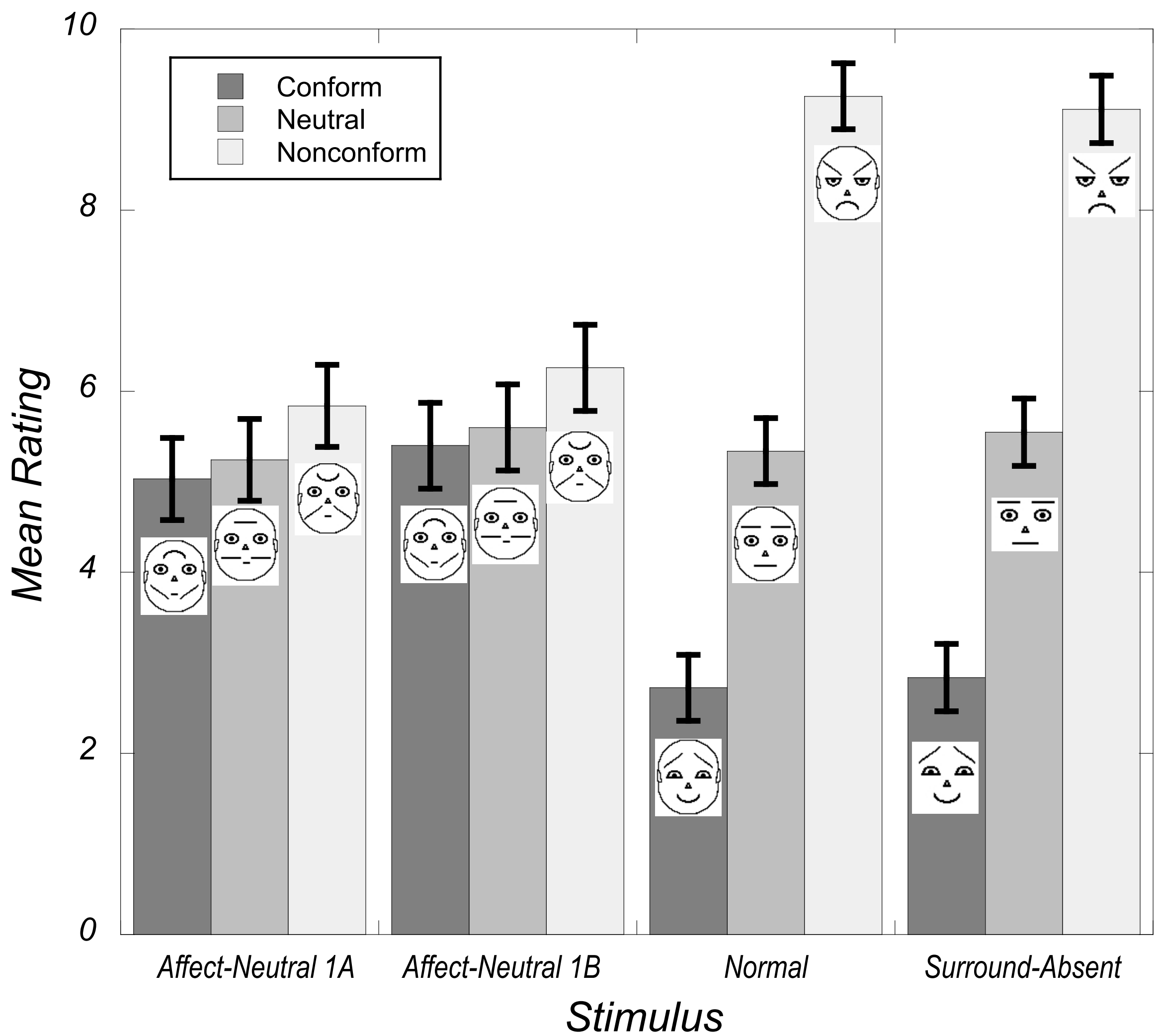

10
8
6
4
2
0
Mean Rating
Conform
Neutral
Nonconform
Affect-Neutral 1A
Affect-Neutral 1B
Normal
Surround-Absent
Stimulus

Figure 3

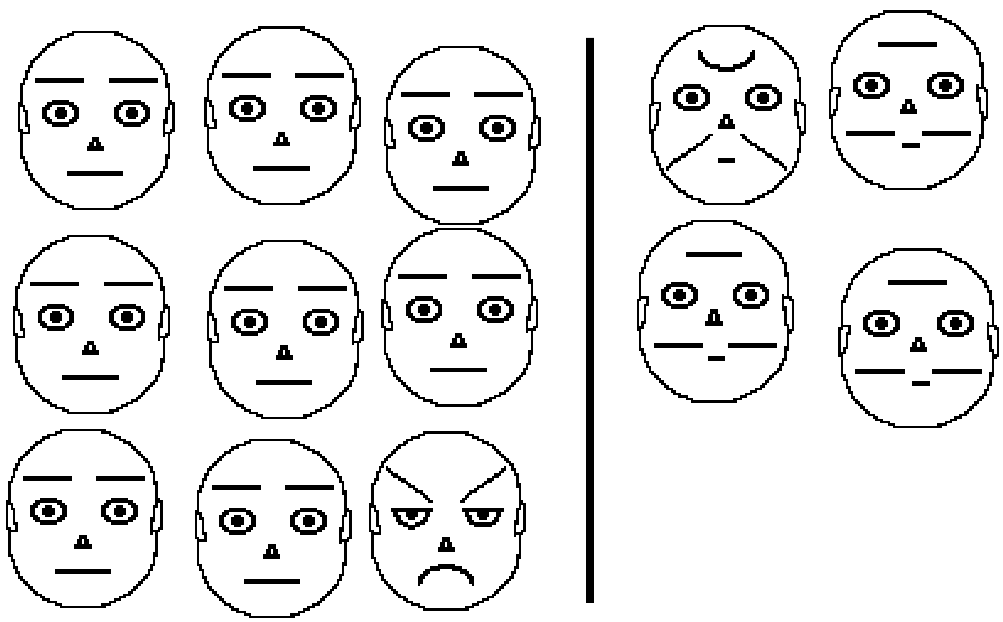


Figure 4

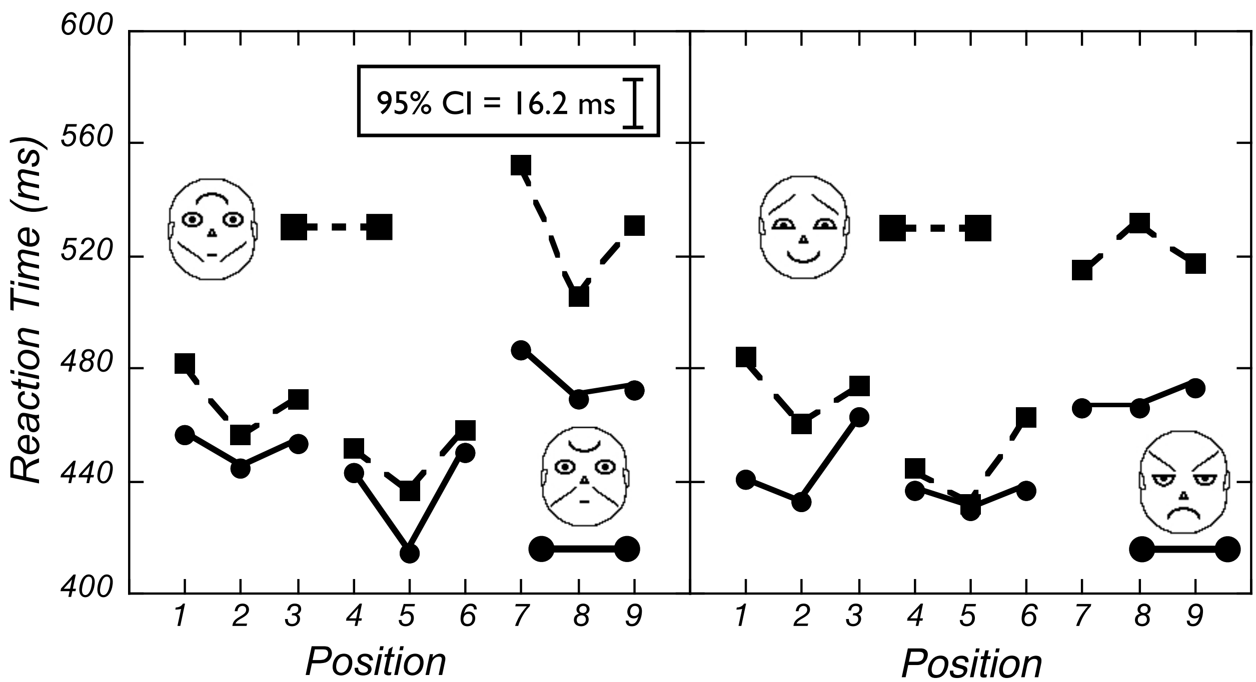

600
560
520
480
440
400
Reaction Time (ms)
95% CI = 16.2 ms
1 2 3 4 5 6 7 8 9
Position
1 2 3 4 5 6 7 8 9
Position

Figure 5

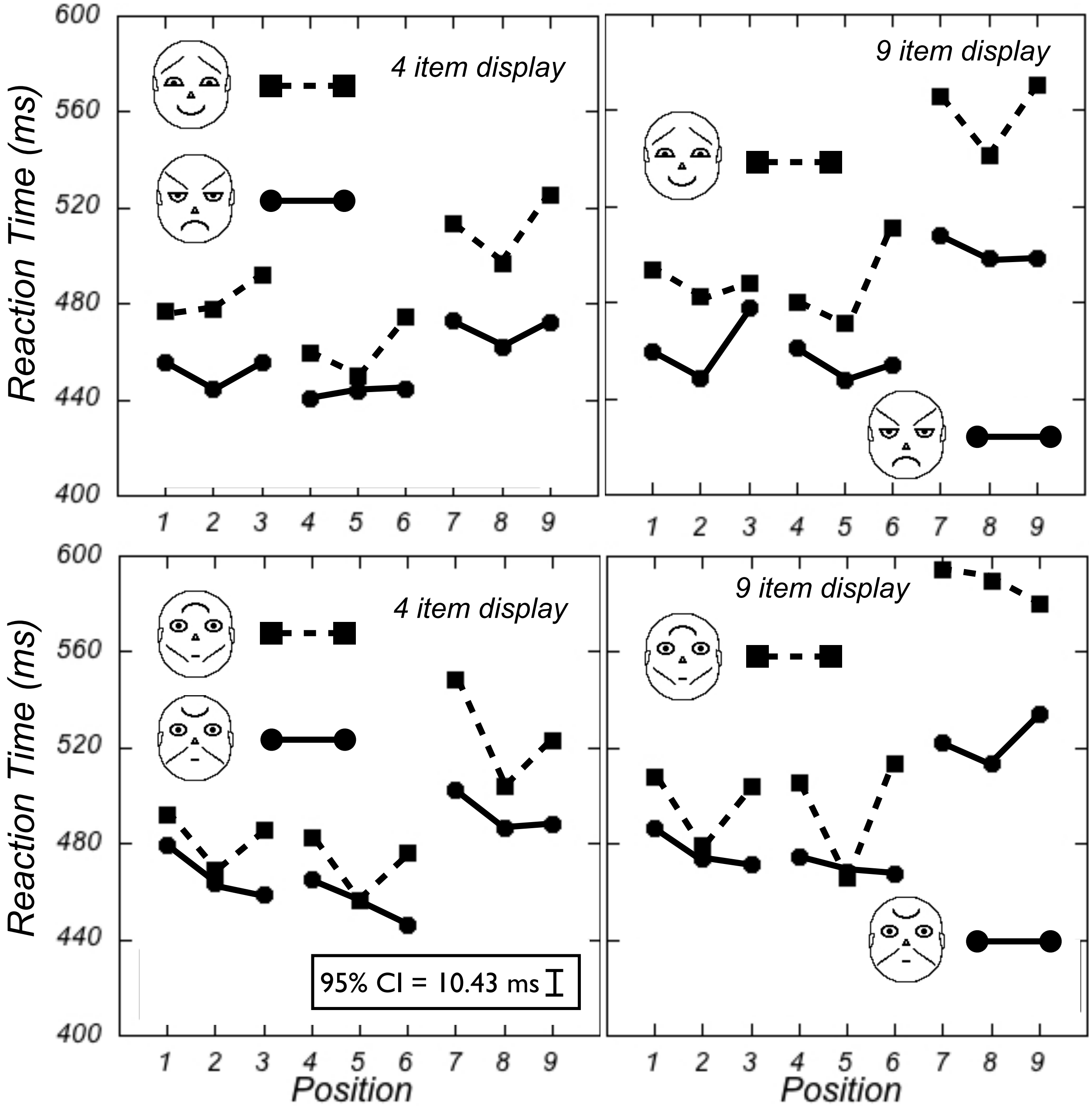

4 item display
9 item display
4 item display
9 item display
Reaction Time (ms)
Reaction Time (ms)
600
560
520
480
440
400
1 2 3 4 5 6 7 8 9
Position
Position
95% CI = 10.43 ms

Figure 6

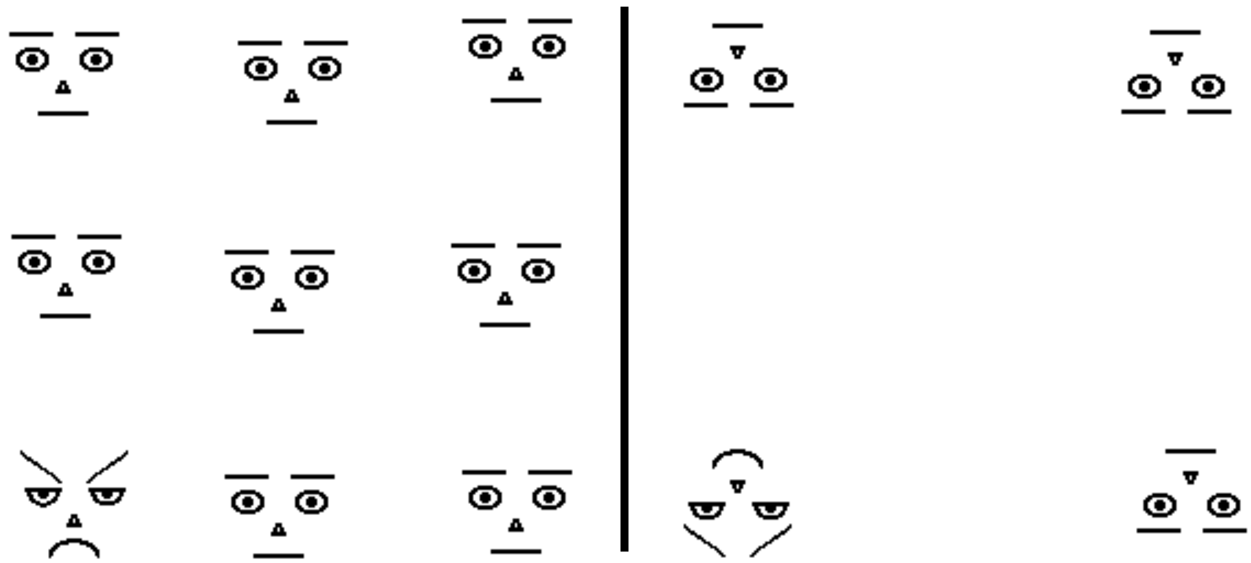


Figure 7

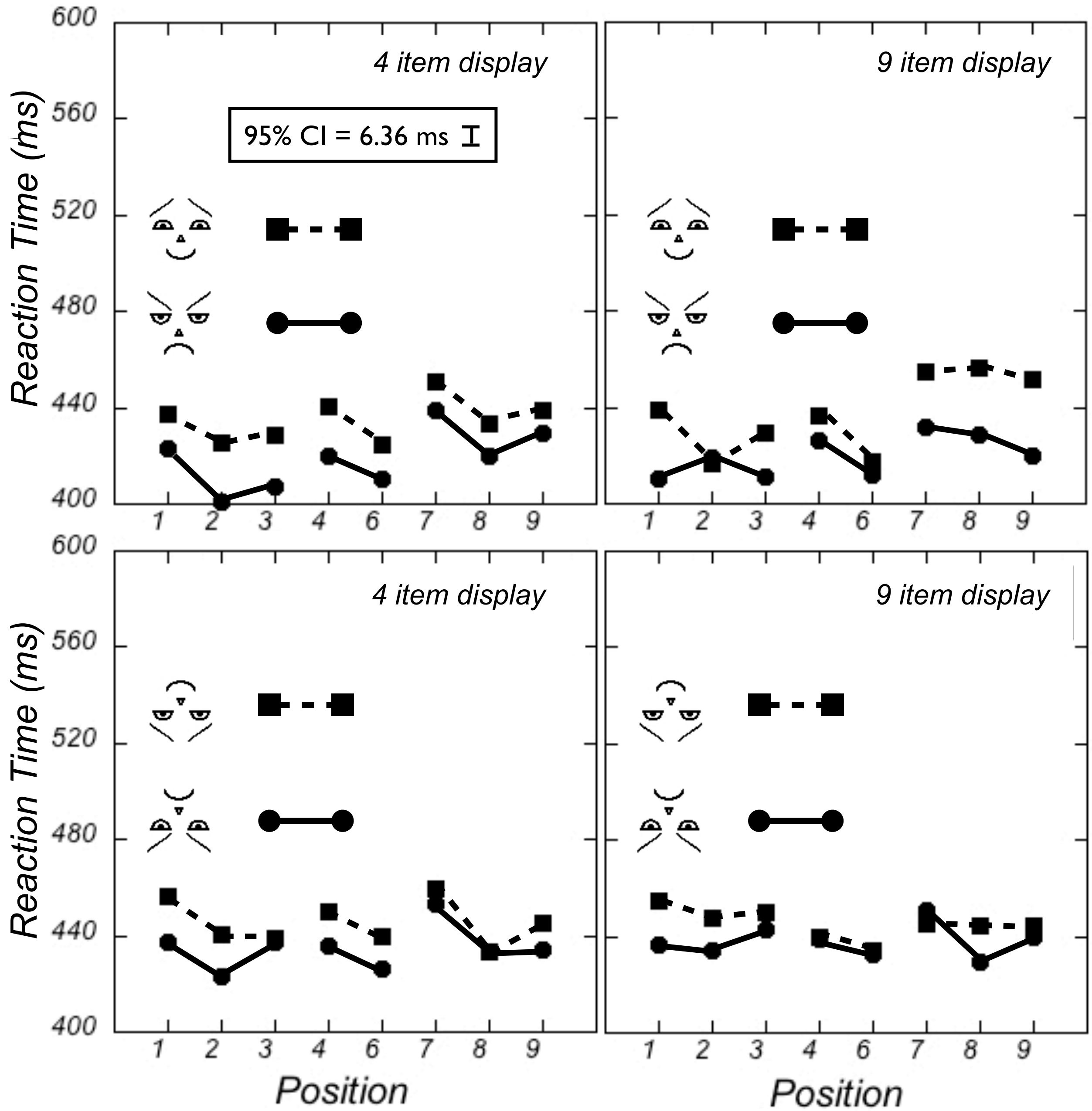
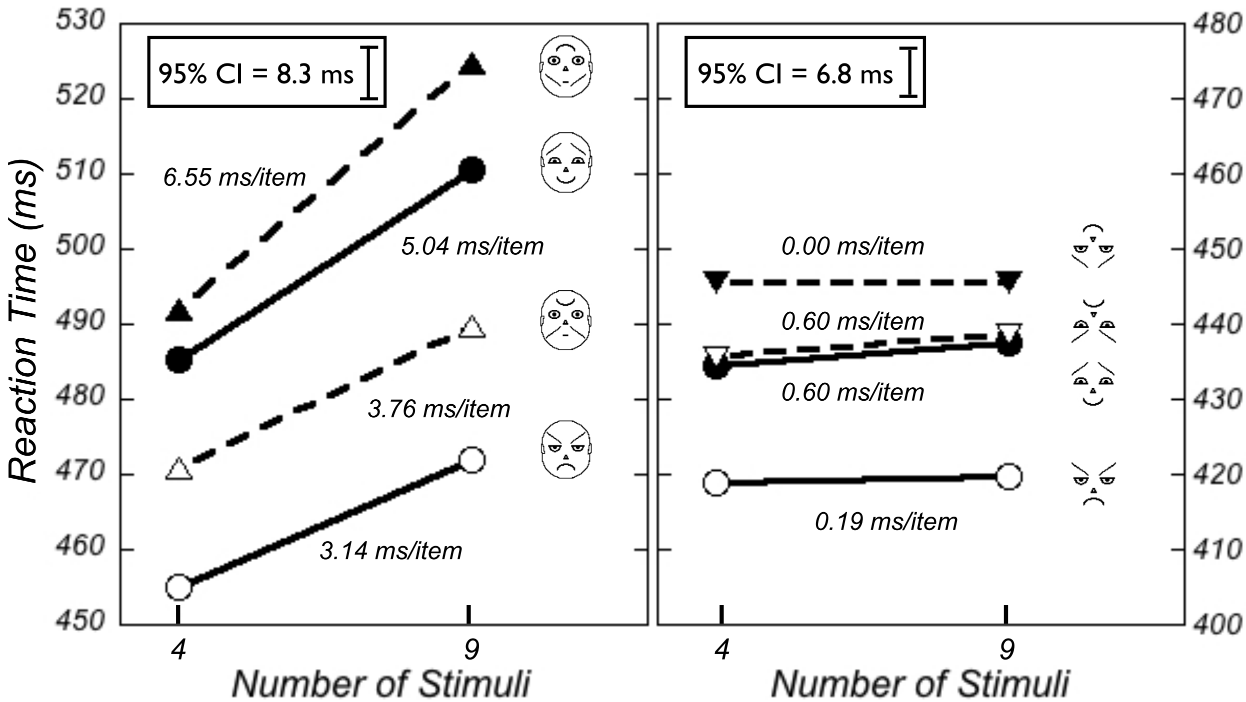

4 item display
9 item display
95% CI = 6.36 ms
Reaction Time (ms)
600
560
520
480
440
400
1 2 3 4 6 7 8 9
Position
4 item display
9 item display
Reaction Time (ms)
Position

Figure 8


95% CI = 8.3 ms
95% CI = 6.8 ms
Reaction Time (ms)
530
520
510
500
490
480
470
460
450
480
470
460
450
440
430
420
410
400
6.55 ms/item
5.04 ms/item
3.76 ms/item
3.14 ms/item
0.00 ms/item
0.60 ms/item
0.60 ms/item
0.19 ms/item
4
9
Number of Stimuli
4
9
Number of Stimuli