The Effects of the Emotional State of an Observer in the Face in the Crowd Paradigm

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Abstract

The face in the crowd paradigm refers to a particular visual search task in which participants are asked to identify target facial expressions in a crowd of distractors. Previous research in this vein has suggested performance is enhanced for angry faces, an anger-superiority effect. There is however disagreement in many of these findings, and this disagreement may partly be explained by a failure to recognize the role of observer mood, response bias, and discrimination ability in the paradigm. The present study used a face in the crowd visual search task and assessed participant mood state using the Positive and Negative Affect Schedule. We hypothesized that mood state would be congruent to facial expressions most efficiently perceived. Multivariate analyses of variance showed instead that positive mood is associated with faster response times in emotional crowds, and negative mood is associated with faster response times in neutral crowds. A strong "no target present" response bias was also associated with neutral crowds, and this response was exacerbated by negative mood. These results suggest that mood does play an important role in visual search, one that may explain contradictory findings in the previous literature.

Introduction

A hunter in a field hears a footstep. He looks forward and sees the threatening grimace of another hunter, and flees the scene. In the reverse scenario, he instead finds a welcoming grin of a gatherer, whom he approaches in hopes of food. Which of the two facial expressions did our hunter perceive with greater efficiency?

Past research has offered some insight to which emotions are perceived with greater efficiency. It was first hypothesized that threatening faces would be more easily perceived in a crowd of distractors (Hansen & Hansen, 1988). The researchers developed a visual search task (the "face in the crowd" paradigm) in which participants searched a crowd of nine faces, which displayed either the same facial expression throughout or a discrepant facial expression. They found that when angry faces were embedded into crowds comprised of one distractor emotion (eight happy or neutral faces), they were found more efficiently than the other emotion when embedded in angry faces. The results of the study suggested an "anger-superiority" effect.

The results were later found to be questionable. Hansen and Hansen used photos of nine individuals that were then gray-scaled to reduce possible variability introduced from differences in brightness/hue. In this exercise, they unwillingly introduced gray smudges on the chins of the stimuli they used. When the smudges were removed from the same stimuli, no anger-superiority was apparent (Purcell, Stewart, & Skov, 1996). Though the unwanted variable may have invalidated their results, the study did succeed in inspiring further investigation.

Since Hansen and Hansen's pioneering work, many researchers have turned their attention to this problem. In support of the anger-superiority effect are several replications that use human photo stimuli. A similar visual search paradigm found another anger efficiency advantage, supporting the previous finding (Fox & Damjanovic, 2006). The same researchers also found that the eyes of their stimuli were enough to produce the advantage. Their conclusion was that it was the eye-region alone that produced the effect. In the same year it was found that angry faces were more quickly detected than were happy ones when the two expressions were displayed side-by-side (Hortsman & Bauland, 2006). These researchers found that the mouths (and not the eyes) in their stimuli were sufficient to produce the effect, and so came to the opposite conclusion as Fox and Damjanovic.

Pinkham, Griffin, and Baron (2010) found an anger-superiority effect in another visual search experiment using human photo stimuli. Specifically they found that angry faces were found with significantly greater accuracy (84.9%) than were happy targets (74.4%), and that neutral crowds facilitated easier searches than did emotional crowds. It has also been shown that when angry and happy human photo stimuli are fused to create “intermediate” distractors, an anger superiority effect is again evident, in that angry faces are detected faster and with greater accuracy (Krysko & Rutherford, 2009). This research also found a main effect of crowd size, with increasing reaction times coming from increasing crowd sizes.

The amount of possible variables associated with facial expressions has caused some researchers to investigate the problem using schematic faces instead of human photos. Nothdurft (1993) investigated the problem using irregular matrices of happy and sad schematic faces, and found no effect. In contrast, Fox, Lester and Russo et al. (2000) found that when angry and happy schematic faces were displayed, participants showed anger-superiority in both reaction times and accuracy. These researchers note that no effect was evident when faces were inverted, or when the eyebrows were removed from their stimuli.

A similar result is found when using angry, neutral, and happy schematic images (Ohman, Lundqvist, & Esteves, 2001). The researchers found an anger-superiority effect in five different experiments, and one is of particular interest. When using “scheming” faces (with smiles and eyebrows tilted downward), anger superiority was again noted, and so the researchers concluded it was the threat, not the negative valence, of the stimuli that produced the effect. These results were seemingly replicated when an anger-superiority effect using schematic stimuli in both young (mean age = 20.3, N = 33) and old (mean age = 72.5, N = 35) individuals was found (Mather & Knight, 2006). The lack of a difference between these groups led the latter researchers to believe age does not factor into automatic facial processing.

These results were later challenged (Purcell & Stewart, 2010). The researchers performed a visual search study using Ohman et al.’s stimuli and found that when the border of these stimuli was removed, no anger-superiority was evident. They concluded that because of the interaction between the border and the eyebrows in the schematic stimuli used, the angry faces were more efficiently detected. If the claim is in fact the case, then the validity of many of these schematic stimuli experiments is in jeopardy.

Juth, Lundqvist and Karlsson et al. (2005) conducted a visual search experiment that produced results contrary to the anger-superiority effect. In a task in which happy, angry, and fearful faces were presented, happy faces were more quickly and with greater accuracy than were the others. Becker, Anderson and Mortensen (2011) found many similar results using human photo stimuli. In two different visual search tasks, using whole, open-mouth stimuli and the same stimuli without the bottom half of the face, a happiness superiority effect was evident in both accuracy and reaction times. The researchers also used a closed mouth set of human photo stimuli to produce a similar happiness-superiority effect. This study also used Poser 4 software to create computerized facial stimuli with an equivalent number of changes from neutral to emotional (either happy or angry), and in a visual search task found the happy faces were more quickly than others.

When using pictures from the NimStim Set of Facial Expressions that displayed open-mouthed expressions, an anger-superiority effect in the form of both reaction time and accuracy is evident (Savage, Lipp, & Craig et al., 2013). When these researchers used Ekman and Friesen's 1976 set of human photo stimuli in the same search task, happiness superiority was instead evident. The study seems to suggest that even the set of human photo stimuli used could affect the efficiency of facial processing.

The nature of the distractor stimuli also plays a role in facial perception efficiency (Ohman, Juth, & Lundqvist, 2010). When distractors were more familiar (i.e., when the stimulus set was small) search performance was better overall. The effect interacted with both the target's gender and emotion, such that female happy faces were found more efficiently, and that happiness superiority effects were present when male targets were among "non-redundant" (i.e., when the stimulus set is large) distractors. With regard to the latter finding, the opposite was the case when the stimulus set was large, and males who displayed angry faces were found more efficiently. The research suggests that both crowd effects and gender of the stimuli also play a role in facial processing.

In the research aimed at the problem of facial expression perception there has been a large focus on the perceptual features of the stimulus to be perceived. Though it is an important research avenue, there is another equally important avenue that has been neglected. In 2008, Frischen, Eastwood, and Smilek conducted a literature review on the topic and came to three conclusions: visual search is sensitive to the emotional expression of a face, affective meaning (as well as perceptual features) of a face can guide attention, and the affective state of the observer influences visual search for emotional faces. Though all three offer important insights, the important conclusion for our sake is the third. This conclusion was drawn by considering the evidence from research investigating the role of psychopathy in visual search. I'll now turn to this literature to defend their third conclusion.

In 2009, Krysko and Rutherford continued their research by running the same visual search paradigm with children with and without autism spectrum disorder. They found that the control group and the autism group performed similarly in the task; the two groups showed a reaction time anger-superiority effect, but only the children in the control group displayed an accuracy advantage. Rosset, Santos and Da Fonseca (2011) seemingly replicated the result, and found the same type of anger-superiority effect in both autistic and control conditions. The two studies were similar in that each used human photo images and a visual search task, but the emotions included in each are slightly different. In the 2009 study, happy, angry, and "intermediates" (from their earlier work in that year) were used, while only happy and angry faces were used in the 2011 study. The research seems to suggest that persons with autism spectrum disorder display weaker, but intact, emotional processing mechanisms, which would agree with the symptomology of ASD.

When using happy, neutral, angry and disgusted human photo stimuli, participants with general social phobia produce larger anger-superiority effects than do the control group, though the controls did show the effect as well (Gilboa-Schechtman, Foa, & Emir, 1999). They also note that those with social phobia were more affected by the emotionality of the crowd of distractors (as opposed to the neutrality) than were controls. In 2012, Ashwin, Holas, and Broadhurts et al. conducted another paradigmatic study with participants that had generalized anxiety disorder and panic disorder, as well as a control group. The results suggested greater anger-superiority effects exist for the disordered populations than do for controls. Both disorders also showed crowd dependent effects.

These studies suggest that the emotional state of the observer may have a significant effect on perceptual efficiency. Thus far however, most research investigating the effect of mood on visual search for emotion has focused on comparing clinical populations to controls. The present study aims to investigate the role of the affective state of the non-clinical observer while performing normal search. To do so, we will employ the Positive and Negative Affect Schedule (PANAS), a 20-item mood scale assessing positive and negative affect (Watson, Clark, & Tellegen, 1988). The PANAS asks participants to rate from 1-5 how accurately 10 positive mood words (such as interested, proud, etc.) and 10 negative mood words (such as irritable, jittery, etc.) describe their mood state over a given time period. The scales were chosen because they fit the "happy versus angry" visual search paradigm well, and because they've been well verified in cross-cultural studies. In 1999 Sandin, Chorot and Losato et al. found a stable, two-dimensional structure between the positive and negative PANAS scales an aim of the developers), and high construct validity and reliability in a Spanish sample (N=712). In 2003 Terracciano, McCrae, & Costa again found high construct validity, reliability, and a two-dimensional structure in an Italian sample consisting of 600 participants. A similar study was conducted in 2004 by

Crawford and Henry, in which high reliability and validity were reported, as well as invariance across a population of 1003 participants from the United Kingdom. The simplicity of the PANAS, as well as its high cross-cultural validity and reliability, make it a worthy candidate for measuring the affective state of the observers in our experiment.

We elected to use create stimuli from The NimStim Set of Facial Expressions, a set of colored facial expression stimuli developed by Tottenham, Tanaka, and Leon in 2009. Tottenham et al. (2009) developed a set of facial stimuli they felt offered a great deal of improvements from past facial stimuli sets. Most importantly for this study was the fact that stimuli were in color. We chose to use colored stimuli to further increase ecological validity, and because research in this area has lacked colored stimuli thus far. In Tottenham's study above, participants were asked to determine the emotion that was being expressed in each of the 672 photos, and the researchers found the mean proportion correctly detailed was 79%. The proportion correctly detailed of the stimuli used in this experiment was 87% for angry closed mouth faces, 92.5% for happy closed mouth faces, and 95.5% for neutral closed mouth faces.

It is plausible that the mood state of the observer can affect visual search efficiency, because it has been shown in other paradigms. In a person description memory task, participants with a manipulated sad or happy mood more quickly recall persons that are associated with mood-consistent descriptions (Forgas & Bower, 1987). Negative mood states induced through music have also been shown to amplify the perception of sadness, and impair the perception of happiness, in emotionally ambiguous faces (Bouhuys, Bloem, & Groothuis et al., 1995). However, it has also been shown that participants manipulated to have a sad mood less accurately identify negative facial expressions than neutral ones

(Chepenik, Cornew, & Farah, 2007), suggesting instead that mood state is inversely associated with facial expressions easily perceived. These findings together suggest that mood state does impact the perception of emotionally relevant stimuli, and so it seems necessary to investigate the role of observer mood in the face in the crowd paradigm.

To our knowledge, no face in the crowd study has considered the impact of discrimination ability and response bias on accuracy data. It is important to differentiate between these to better understand the differences that may be seen in accuracies between participants, and how these differences change as a function of mood state. Essentially, discrimination refers to the ability to distinguish between target trials and non-target trials, while response bias refers to the overall probability of responding “target” vs. “non-target” regardless of the actual trial type. Accuracy alone can be deceiving. A participant who always responds “target” (a liberal response bias) will have 100% accuracy on target trials and 0% accuracy on non-target trials, but exhibits no true sensitivity in discriminating between targets and non-targets. Signal detection theory allows us to independently measure discrimination (with a measure called d’) and response bias (with a measure called c). A d’ value of zero indicates no true sensitivity in discriminating targets from non-targets, as in the above example. A c value of zero indicates no response bias, a positive c is a conservative response bias (favoring “non-target” responses) and a negative c is a liberal response bias (favoring “target” responses) as in the above example.

Negative mood has been shown to affect discrimination and response bias in previous literature. Compared to healthy volunteers, people with depression demonstrate impairments in discrimination and a response bias away from identifying happy facial expressions in a recognition memory task (Surguladze, Young, Senior, Brébion, Travis, et al.

2004). Mood-congruent memory effects in positive and negative verb recognition tests have been associated with discrimination ability, but not to response biases (Fiedler, Nickel, Muehlfriedel, Unkelbach, 2000). It is problematic that past face in the crowd research has neglected to parse out these important variables. We decided to measure and analyze d' (discrimination) and c (response bias) values, and their relation to positive/negative PANAS scores, in order to better understand individual differences in discrimination ability and response bias and their relationships with mood.

The experiment we conducted first measured the affective state of the observer by employing the PANAS mood scales. Afterwards, participants conducted a visual search for happy, angry, or neutral targets in crowds created from the NimStim Set of Facial Expressions. The study used a face in the crowd visual search paradigm similar to those used in previous literature, with multiple distractors and a single target face combined into a matrix. We hypothesize that the emotional state of the observer will be congruent to the facial expression most efficiently perceived, such that a happy observer will more efficiently perceive a happy face in a crowd (and vice-versa for angry faces).

Methods

Participants

60 undergraduates from the University of Colorado Boulder participated in the experiment. Four participants were omitted from the analysis; three were omitted because they were ran in a slightly different pilot version of the experiment, and another was omitted because his/her mean reaction time for correct trials was three standard deviations outside of the overall mean. The participants included in the analysis (N = 56) ranged in age from 18 to 24 years old, with a mean age of 18.98 years (SD = 1.92). 17 males

and 39 females were included in the analysis, and roughly 93% of these participants were right handed. Each undergraduate provided informed consent before the experiment began, as required by the university's Institutional Review Board. Each participant received course credit in exchange for his or her participation.

Materials

The experimental stimuli were created using photographs of 18 Caucasian individuals (9 males and 9 females) from the NimStim Set of Facial Expressions. Each actor displayed three different emotions: happy, angry or neutral. Each of these 54 photos measured 4.13cm (width) X 5.33cm (height). These face photos were then combined into 162 different 3X3 matrices that measured 12.4cm (width) X 16cm (height). The stimuli were in color and expressed closed mouth facial expressions, which were used to control for possible confounds that could come from presenting teeth to participants. 18 practice stimuli using nine males from the NimStim facial set (different than those used in the experimental stimuli) were created in the same way. Examples of experimental stimuli are shown in Figure 1.

The task included 162 trials that were presented to the participants in a random order. One third of the stimuli contained only faces displaying one emotion throughout, producing 18 all happy, 18 all neutral, and 18 all angry trials, or 54 total. The other two thirds of the stimuli included a discrepant face, producing 6 different "target-present" conditions. 108 total trials included a discrepant face (18 trials per target-present condition). Individual photos' positions within the matrices were selected randomly, with two constraints. The matrices included an odd number of faces, 9 total faces were in each matrix. To control for this, half of the matrices were male-dominant, and the other half were female dominant. The second constraint required that individuals appear twice in each position throughout the matrix. The same individual was never used in the same matrix twice.

Figure 1: Examples of the stimuli used in the visual search task. From left to right: 1) A happy target among angry distractors, 2) A happy target among neutral distractors, 3) A happy crowd without a target. Examples were chosen to show all 18 individuals used in creating stimuli.

The Positive and Negative Affect Schedule (PANAS) is a twenty-item mood scale that was created in 1988 by Watson and Clark. The PANAS lists ten positive and ten negative words and asks the participant to use a 1-5 rating scale to describe how accurately the words describe their current mood state. The minimum score for each dimension is 10, and the maximum is 50. An example of the PANAS mood scale used in the experiment is shown in Figure 2.

Apparatus

The experiment was conducted using 21.5inch iMac computer with a 2.7GHz Intel Core i5 processor. A refresh rate of 60MHz and a resolution of 1920 X 1080 pixels were used throughout the experiment. The apple hardware was booted into Windows 7 at the hardware level, to avoid possible millisecond communication discrepancies between software and system. The software that delivered the stimuli to the participant was E-

Prime Subject Station version 2.0.10.356. Responses were recorded using an apple keyboard that was modified to be accurate to the millisecond by the company "empirisoft". Three keys were activated in the experiment, the two response keys "s" and "l", and the "space" key for moving between trials.

This scale consists of a number of words that describe different feelings and emotions. We are interested in the degree to which you are experiencing each feeling or emotion **RIGHT NOW**. Read each item, appropriate number from the scale below next to each statement to indicate your answer.

1	2	3	4	5
Very slightly or not at all	A little	Moderately	Quite a bit	Extremely

_______ 1. Interested

_______ 2. Distressed

_______ 3. Excited

_______ 4. Upset

_______ 5. Strong

_______ 6. Guilty

_______ 7. Scared

_______ 8. Hostile

_______ 9. Enthusiastic

_______ 10. Proud

_______ 11. Irritable

_______ 12. Alert

_______ 13. Ashamed

_______ 14. Inspired

_______ 15. Nervous

_______ 16. Determined

_______ 17. Attentive

_______ 18. Jittery

_______ 19. Active

_______ 20. Afraid

Figure 2: The Positive and Negative Affect Schedule used in the experiment. Items 1, 3, 5, 9, 10, 12, 14, 16, 17, and 19 were used to score positive affect, while items 2, 3, 6, 7, 8, 11, 13, 15, 18, and 20 were used to score negative affect.

Design

The experiment used a within-subject design and manipulated the emotionality of the crowd and target faces within the crowd. The independent variables were the nine different emotional conditions, six of which were target-present conditions: happy-angry, happy-neutral, neutral-happy, neutral-angry, angry-happy, and angry-neutral (where the first emotion in the notation describes the crowd and the second emotion describes the target). The three remaining conditions were target absent with all angry, all happy, or all neutral faces. Each participant in the experiment was exposed to 18 trials of each condition, and the order of presentation was randomized for each participant. The dependent variables measured were reaction time, accuracy, d', c, and the positive and negative scores of the PANAS questionnaire.

Procedure

Participants first completed their consent form, a demographic survey, and the PANAS questionnaire in a staging room, and were then lead to a small experiment room. An experimenter gave verbal instructions to each participant, instructing them to press the 's' key if the crowd presented contained the same emotion throughout, and to press the 'l' key if the crowd presented contained more than one emotion throughout. The experimenter also explained that the experiment is participant-paced, and that after each trial they should press the space bar to continue. After these verbal instructions, the participant sat in front of a computer in a small room, roughly 60 cm away from the monitor. After reading similar on-screen instructions the participants began the practice experiment.

To orient participants to the task, 36 total practice trials were ran using 18 total stimuli. These practice stimuli consisted of nine different males from the NimStim Set of Facial Expressions, each one expressing three different emotions. The crowds created from these photos were the same size as the experimental crowd stimuli; they were also in color and displayed closed mouth facial expressions. The first half of the practice trials gave the participant visual feedback on accuracy and reaction time, while the second was a replication of the actual experiment. The participants were told to inform the experimenter once they had completed the practice experiment, so that any last questions regarding the task could be answered. Once the participant was ready, the experimental trials began.

Trials began with a fixation cross that was presented for 500ms in the center of the screen. After this time the cross was replaced by a matrix crowd of faces that stayed on the screen for 2000ms. After two seconds of stimulus, the screen then switched to a text screen that showed key assignments (the screen read: s = same, l = diff). The participant was instructed that they should respond as quickly and accurately as possible, and that they could respond before or after the stimulus had left the screen. After the participant responded, the word “Next” appeared on the screen to indicate that they could move on to the next trial by pressing the space bar when they were ready. After the experimental trials were completed, the participant left the room and received a debriefing form and course credit. The entire session lasted roughly 30 minutes.

Results

In the sake of brevity, we have only reported statistically significant ($p < .05$) and marginal ($p < .10$) results below. Any results not mentioned below can safely be assumed to be not significant. Only correct trials were included in the reaction time analyses. Median splits on positive and negative PANAS scores were used to display the data in each of the figures below, but it is important to note that when running each statistical test the PANAS scores were treated as continuous.

Reaction times for emotional target conditions (as well as accuracies, discrimination values, and response bias values) were analyzed in a two crowd condition (emotional, neutral) x two target condition (angry, happy) multivariate analysis of variance (MANOVA) with each participant's PANAS+ and PANAS- scores entered as continuous covariates. For target absent conditions, reaction times and accuracies were analyzed in a three crowd condition (happy, angry, neutral) MANOVA with each participant's positive and negative PANAS scores entered as continuous covariates. Similar analyses were done for neutral target conditions, but they are not reported because no significant (or marginal) mood interaction effects were found.

Reaction Time Results

Reaction times for each emotional target condition are reported in Figure 3.

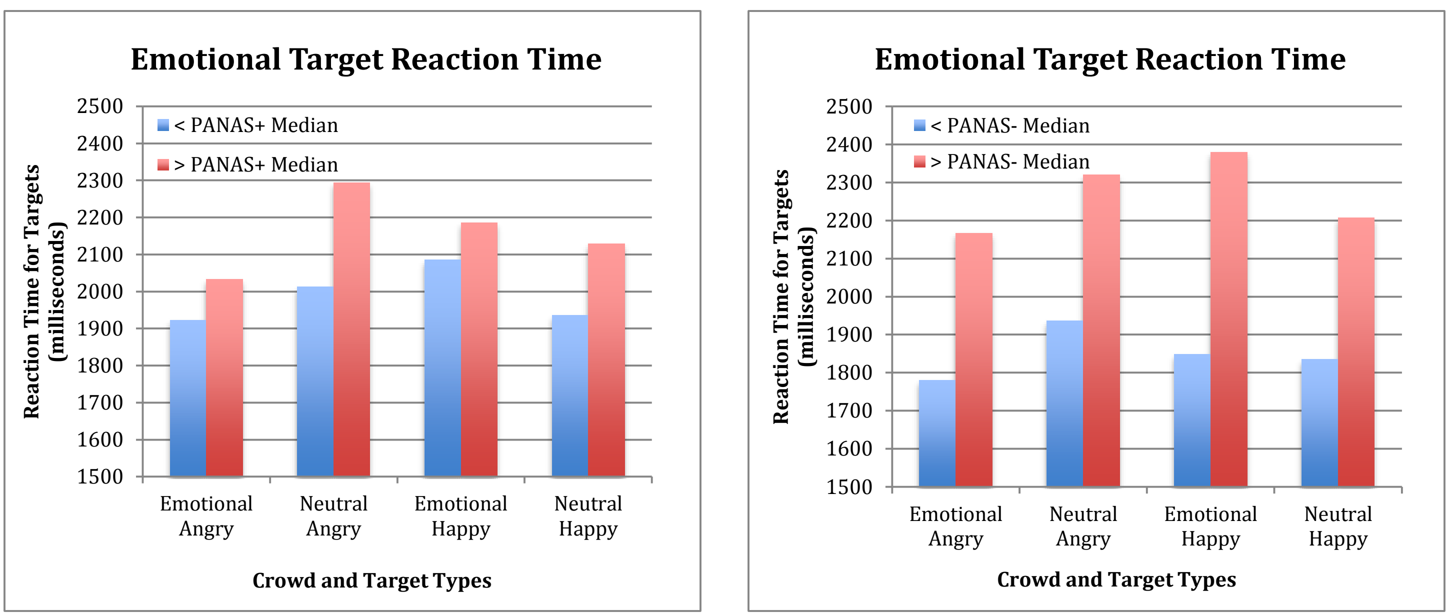
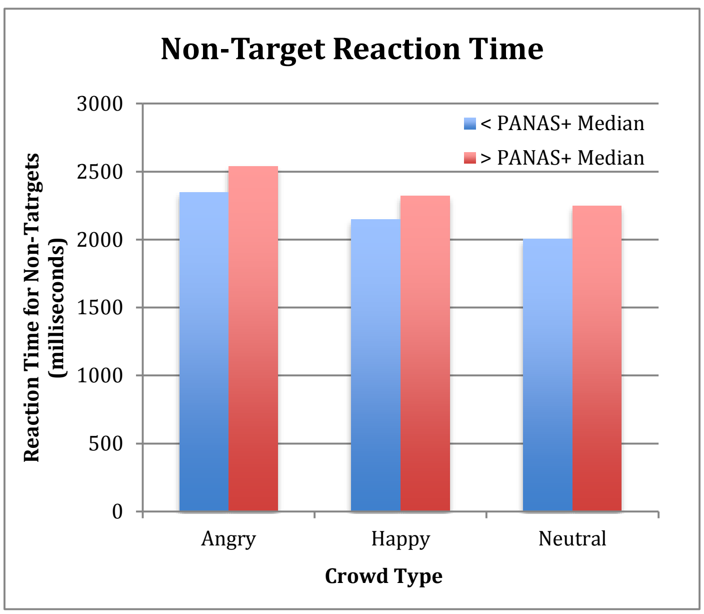


Figure 3: Reaction time results for emotional target conditions, grouped by median splits on positive (left graph) and negative (right graph) PANAS scores. Results are displayed in a median split fashion, but it is important to note that MANOVAs treated PANAS scores continuously. Crowd type is the top word in the notation on the x-axis, and target type is the bottom word.

The reaction time MANOVA revealed a significant interaction between crowd type and positive scores on the PANAS, $F(1,53) = 4.41$, $p = 0.040$. Participants with higher positive PANAS scores were on average 101ms faster when targets were in emotional crowds than in neutral crowds. The opposite was true of lower positive PANAS scores. Participants with lower positive PANAS scores were on average 30ms faster when targets were in neutral than in emotional crowds. There was also a marginal interaction between crowd type and negative scores on the PANAS, $F(1,53) = 3.27$, $p = 0.076$. Participants with higher negative PANAS scores were on average 10ms faster when targets were in neutral crowds, rather than in emotional crowds. The opposite was true of lower negative PANAS scores. Participants with lower negative PANAS scores were on average 71ms faster when targets were in emotional, rather than neutral crowds.

Reaction times for each of the non-target conditions are shown in Figure 4. Another MANOVA resulted in a marginal interaction between crowd type and positive scores on the PANAS, $F(1,52) = 2.64$, $p = 0.081$. Participants with higher positive PANAS scores were on



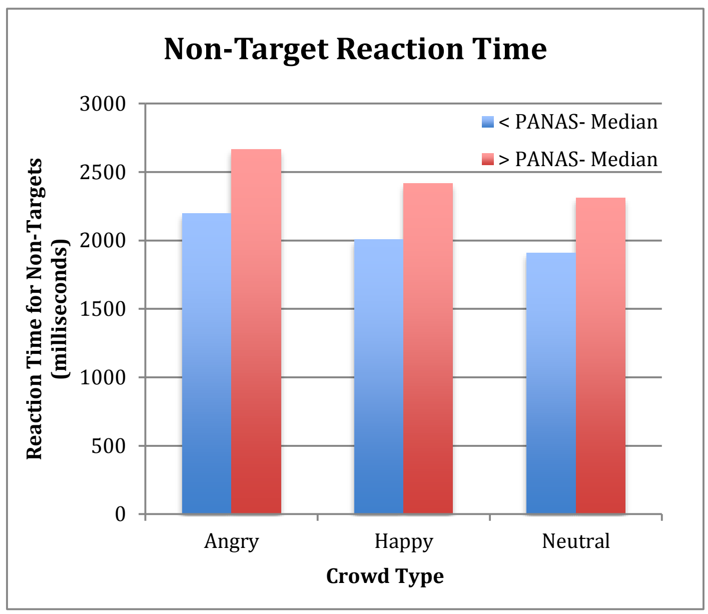


Figure 4: Reaction time results for non-target conditions, grouped by median splits on positive (left graph) and negative (right graph) PANAS scores. Results are displayed in a median split fashion, but it is important to note that MANOVAs treated PANAS scores continuously.

average 288ms faster when identifying neutral crowds compared to angry crowds, and were on average 72ms faster when identifying neutral compared to happy crowds. Participants with lower positive PANAS scores showed a similar, but more pronounced trend, identifying neutral crowds 345ms faster than angry crowds, and 144ms faster identifying neutral crowds than happy crowds.

Accuracy Results

Accuracies for each emotional target condition are reported in Figure 5. The MANOVA showed a significant crowd effect, $\underline{F}(1,53) = 11.73$, $\underline{p} = 0.001$. Participants more accurately identified emotional target faces in emotional (70%) rather than neutral (55%) crowds. There was also a significant interaction between crowd and target types, $\underline{F}(1,53) = 4.10$, $\underline{p} = 0.048$. Participants showed slightly higher accuracy when identifying angry (71%) rather than happy (68%) target faces in emotional crowds, but in neutral crowds the trend was reversed and exacerbated, and participants were instead more accurate when identifying happy targets (64%) rather than angry ones (45%).

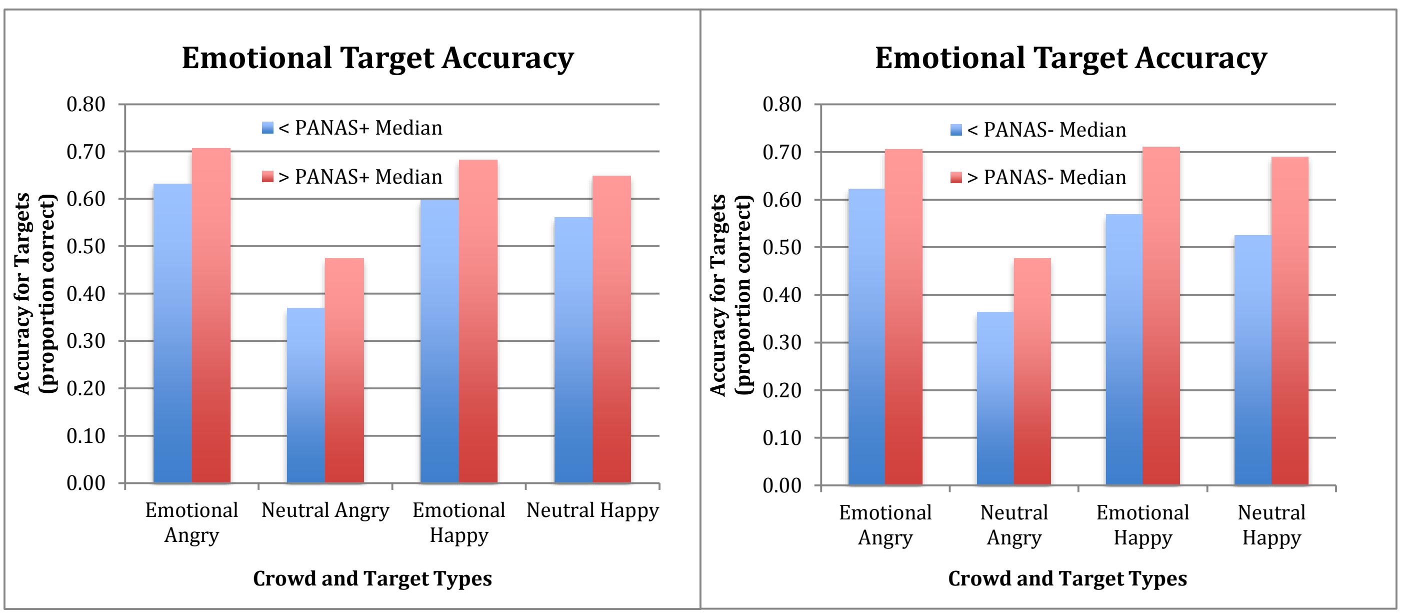


__Figure 5:__ Accuracy results for emotional target conditions, grouped by median splits on positive (left graph) and negative (right graph) PANAS scores. Results are displayed in a median split fashion, but it is important to note that MANOVAs treated PANAS scores continuously. Crowd type is the top/first word in the notation on the x-axis, and target type is the bottom/second word.

Accuracies for each of the non-target conditions are shown in Figure 6. MANOVA results showed a significant crowd effect, $\underline{F}(2,52) = 5.06$, $\underline{p} = 0.010$. Participants were less accurate when identifying an angry crowd (66%) than when identifying either happy

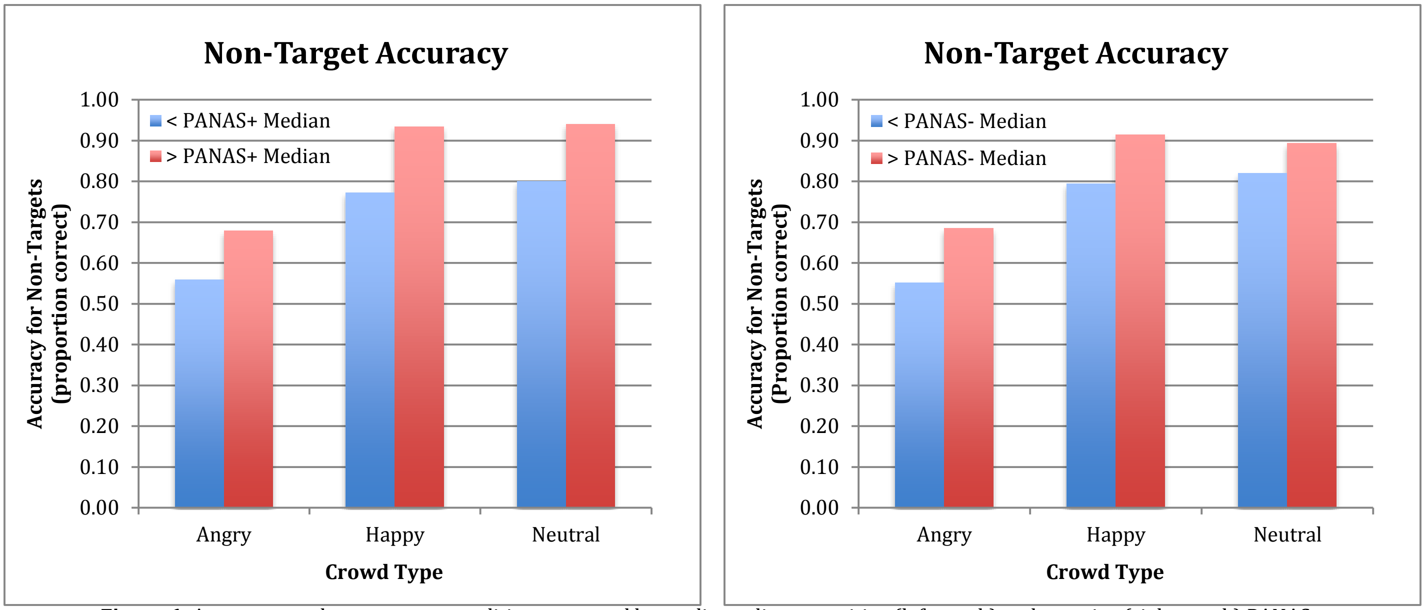


Figure 6: Accuracy results non-target conditions, grouped by median splits on positive (left graph) and negative (right graph) PANAS scores. Results are displayed in a median split fashion, but it is important to note that MANOVAs treated PANAS scores continuously.

(91%) or neutral (93%) crowds. A marginal interaction between crowd and negative scores on the PANAS was also found, $F(2,52) = 2.50$, $p = 0.092$. Participants with higher negative PANAS scores most accurately identified happy crowds (91%), followed by neutral crowds (89%), and then angry crowds (69%). Participants with lower negative PANAS scores showed a similar, but more pronounced trend, most accurately identifying neutral crowds (82%), followed by happy crowds (80%), and then angry crowds (55%).

Discrimination Results

The d' values for each emotional target condition are shown in Figure 7. A MANOVA ran on the d' data revealed a marginal crowd effect, $F(1,53) = 3.06$, $p = 0.086$, as well as a marginal interaction between target and crowd types, $F(1,53) = 3.08$, $p = 0.085$. Participants were more able to distinguish target faces in neutral (d' = 2.07) rather than emotional crowds (d' = 1.75). Participants were more able to distinguish when an angry target face (d' = 2.45), rather than a happy one (d' = 1.05), was embedded into an emotional crowd. In the neutral crowd condition this trend reversed, and happy faces (d' = 2.35) were more readily distinguished than angry ones (d' = 1.78). No significant results were found.

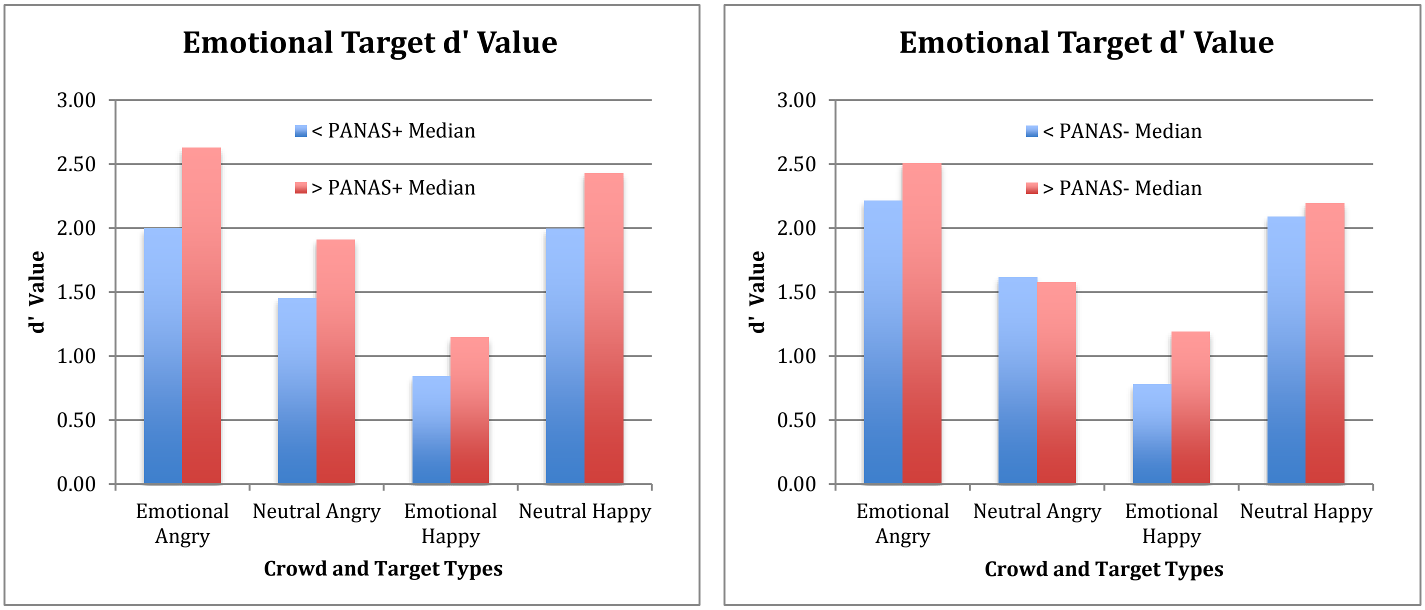


Figure 7: Discrimination (d') results for emotional target conditions, grouped by median splits on positive (left graph) and negative (right graph) PANAS scores. Results are displayed in a median split fashion, but it is important to note that MANOVAs treated PANAS scores continuously. Crowd type is the top/first word in the notation on the x-axis, and target type is the bottom/second word.

Response Bias Results

The c values for each emotional target condition are shown in Figure 8. Positive scores indicate a more conservative (tendency to respond "no") response bias, whereas negative scores indicate a more liberal (tendency to response "yes") response bias. A MANOVA ran on the c data revealed a significant effect of crowd type, $F(1,53) = 15.11$, $p < 0.000$, as well as a significant interaction between crowd type and negative scores on the PANAS, $F(1,53) = 6.02$, $p = 0.017$. Participants were more conservatively biased when identifying target faces in neutral crowds (c = 0.895) than in emotional crowds (c = 0.30). Participants with higher negative PANAS scores were on average less conservatively biased when identifying targets in emotional crowds (c = 0.305) than when identifying targets in neutral crowds (c = 0.695). This trend was more pronounced with participants with lower negative PANAS scores, who were even less conservatively biased when identifying targets in emotional crowds (c = 0.275) than in neutral crowds (c = 0.88).

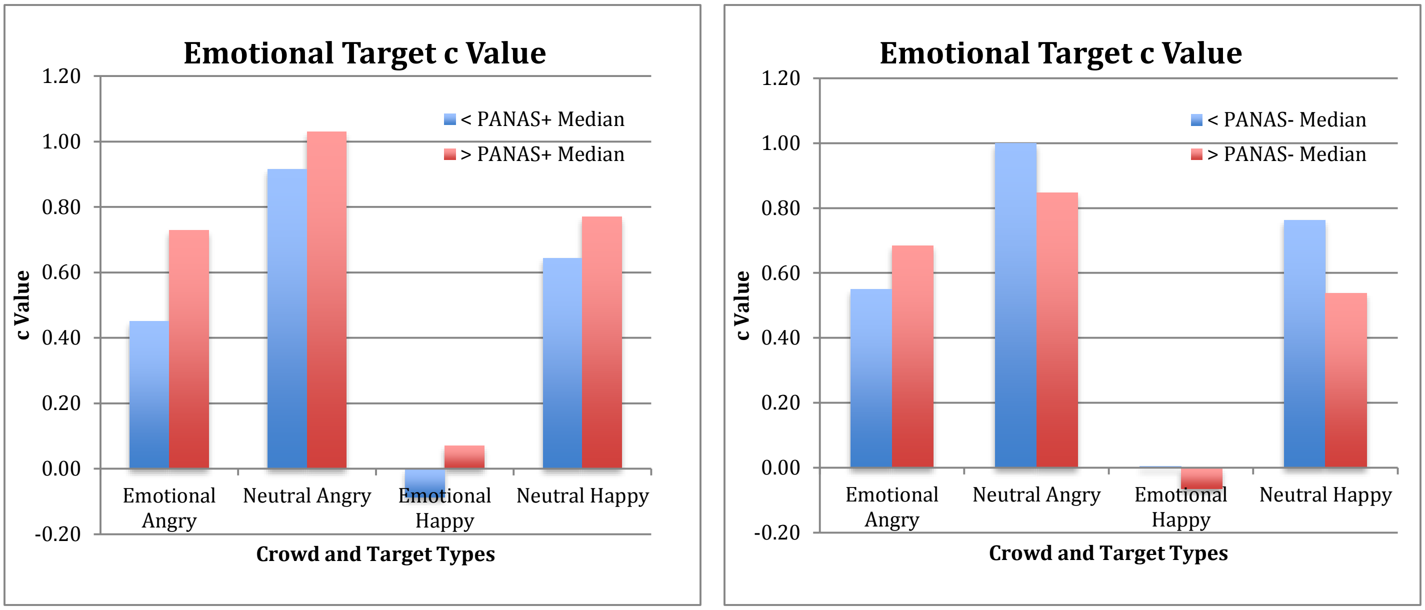


Figure 8: Response bias (c) results for emotional target conditions, grouped by median splits on positive (left graph) and negative (right graph) PANAS scores. Results are displayed in a median split fashion, but it is important to note that MANOVAs treated PANAS scores continuously. Crowd type is the top/first word in the notation on the x-axis, and target type is the bottom/second word.

Discussion

The present study aimed to assess the role of the mood state of the observer in a face in the crowd paradigm that maximized ecological validity by using colored, heterogeneous, human crowds of faces. The study improved on previous literature by considering the role of the mood state of the observer, as well as by analyzing discrimination ability and response bias. We hypothesized that the mood state of the observer would be congruent to the facial expression most efficiently perceived. Our results suggest there is indeed a significant role of observer mood state within the paradigm, though the role was not necessarily congruent. The findings also suggest that crowd emotionality plays a crucial role in the visual search for emotional faces, and that this crowd effect is manifested largely as response bias that is increased as negative affect increases.

Reaction time data suggest that positive affect allows greater search efficiency in emotional crowds of distractors, while negative affect allows greater search efficiency in neutral crowds of distractors. Persons with highly positive affect more quickly identified targets when they were embedded into emotional crowds than when they were into neutral crowds. Persons with highly negative affect showed a marginal, but opposite effect, more quickly identifying targets in neutral rather than emotional crowds. In non-target conditions participants were fastest with neutral crowds, next fastest with happy crowds, and slowest with angry crowds. A marginally significant interaction with positive PANAS scores suggests that these differences might have been somewhat larger for subjects with lower positive PANAS scores.

Accuracy data suggests that the emotionality and the neutrality of a crowd can affect perceptual efficiency, and that negative affect can potentially increase these effects. Target faces were more accurately identified in emotional crowds. When targets were embedded into neutral crowds, happy faces were more accurately identified than angry faces. In non-target conditions participants least accurately identified angry crowds, and this effect was marginally increased with lower negative affect.

The reaction time findings clearly suggest that emotional crowds are perceived with greater efficiency when observer mood state is positive, and that neutral crowds are perceived with greater efficiency when observer mood state is negative. Accuracy findings suggest that less accurate perception of angry faces in non-target conditions seems to interact with low negative affect, although importantly this interaction is only marginal. To better understand the rich accuracy data yielded by the analysis, we must parse out discrimination and response bias.

Only marginal discrimination results were found, but they do suggest that participants are possibly sensitive to the emotion of the stimulus. Observers were more able to distinguish a target face in a neutral crowd. Angry faces were more easily distinguished in emotional crowds, and happy faces in neutral crowds. These data suggest that observers are truly sensitive to angry faces, but that when in neutral crowd contexts they are more sensitive to happy faces. Notably, d' never significantly interacted with subjects' level of positive or negative affect on the PANAS.

Response bias results strongly suggest that neutral crowds are associated with greater observer "no" bias to claim that a target face is absent. They also argue that low negative affect can increase this observer response bias, such that the bias difference between crowd types increased for participants with lower negative affect.

Although we observed several effects on accuracy, as summarized above, breaking those accuracy results down into separate discrimination (d') and response bias (c) influences revealed that the accuracy effects were primarily due to response bias rather than discrimination. The RT and response bias results can be seen as complimentary. Subjects in a negative mood state (high PANAS- (RT, c) and low PANAS+ (RT)) are faster to respond to targets in neutral than emotional crowds and somewhat biased against making "target" responses in neutral crowds more so than emotional crowds. Subjects in a positive mood state (low PANAS- (RT, c) and high PANAS+ (RT)) are faster to respond to targets in emotional than neutral crowds and more extremely biased against making "target" responses in neutral crowds than emotional crowds. Thus, negative moods lead to faster responding in neutral than emotional crowds, and positive moods lead to faster response in emotional than neutral crowds, but positive moods are additionally associated with a large bias against making target responses in neutral crowds. The RT and response bias effects in those with positive moods (or low negative moods) might be considered together to reflect a reluctance of these subjects to make target responses to neutral crowds which leads to both a conservative response bias and slower RTs in neutral crowds. Considered separately, reaction time effects might reflect emotional effects on perception or attention, while response bias effects might reflect emotional effects on decision-making processes that have yet to be documented in the paradigm.

There are several disagreements in findings between previous face in the crowd studies that are relevant to our work. An important example is evident in target effect findings. Though most paradigmatic studies have found target effects, some have reported happy target advantages (Becker et al., 2011; Juth et al., 2005; Savage et al., 2013), and others have reported angry target advantages (Hansen & Hansen, 1988; Pinkham et al., 2010), both in the form of reaction time and accuracy. In the present study, no main effect of target emotion is seen.

The present studies' crowd effect findings highlight another conflict. It has previously been shown that targets are found more quickly and accurately in neutral crowds of distractors (Pinkham et al., 2010), but the reverse effect is seen in our data. We found a significant effect of crowd only on accuracy, and it was that targets were found with greater accuracy in emotional crowds of distractors. However, there was some agreement between the 2010 study and our own results; a target-crowd interaction resulted in more accurate identification of happy faces than angry faces in neutral crowds in both experiments.

There are also conflicts in target absent findings present in the literature. Some studies have suggested that neutral crowds of distractors are identified more accurately (Ashwin et al., 2006, 2012; Hansen & Hansen, 1988) than other emotions, and our own results agree. However, there is evidence that suggests instead that happy crowds of distractors are identified with greater accuracy (Pinkham et al., 2010). Most of these studies agree that angry faces are the least accurately and slowest identified, but even this seemingly fundamental finding was questioned by Ashwin et al. (2012), when happy faces were instead shown to be least accurately and slowest identified.

The presence of these conflicting findings in the paradigm might suggest that there is something fundamentally different between each particular study. It could be that the emotional state of the observer could be the driving force of these conflicting results. Our results suggest that mood does indeed affect participant performance in the face in the crowd paradigm. To truly understand the perception of facial expressions, researchers in the future should consider the implications of the emotional state of the observer.

Directions for Future Research

Our results suggest that both stimulus and subject emotions can influence perception and attention processes, but employing a purely behavioral face in the crowd paradigm does not allow us to make claims about the effects of emotion on each separately. It could be that the effects of mood on response bias and reaction times found in the present study are affecting attentive or perceptual processes. There are two potential avenues for future research that would shed light on the role of each in the face in the crowd paradigm. Electroencephalography and eye-tracking experiments could be conducted to better understand the way attention and perception interact with mood.

Further neuropsychological research is necessary to gain a full understanding of attention in the face in the crowd paradigm. ERP studies in the face in the crowd paradigm have suggested that threat relevant stimuli showed that a larger N2pc component than for threat irrelevant stimuli, and that this component had an earlier onset for threatening stimuli (Feldmann-Wustefeld, Schmidt-Daffy, & Schubo, 2011; Weymar, Low, & Ohman et al., 2011). This N2pc component has also been previously associated with selective attention. In visual discrimination tasks in which participants were asked to identify either a letter, colored square, or word among distractors, an enhanced N2pc was recorded at posterior electrodes contralateral to the attended targets (Eimer, 1996). Additional EEG research could show how mood effects on response bias and reaction time are related to this N2pc component, and would therefore allow further claims about how attentive processes are affected.

To fully understand how perception is affected by the mood of the observer, further eye-tracking research may be helpful. Previous eye-tracking research in the face in the crowd paradigm has suggested that the perceptual features of the target face are more important than those of distractor faces (Shasteen, Sasson, & Pinkham, 2014). These results seem to conflict with our finding that distractor crowds play a more important role. This conflict may have been the result of variable mood states between the two studies. There is eye-tracking research that suggests that depressed populations gaze longer at dysphoric images than do healthy populations. (Kellough, Beevers, & Ellis et al., 2008). Additional eye tracking research would allow researchers a better understanding of perceptual processing of facial features and how this processing is affected by the mood of the observer.

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