DETECTABILITY AND PERCEIVED DEGREE OF FACIAL HAPPINESS, ANGRINESS, AND EMOTION: THE ROLE OF THE PARTICULAR STIMULI

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Abstract

The purpose was to elucidate further Pixton's (2007, 2008) results. Thirty participants (8 men, 22 women) viewed pictures of facial expressions (Tottenham et al., 2009) with three presentation times (12.50, 18.75, 25.00 ms) and completed a detection (Part 1) and a rating (Part 2) task. In Part 1, participants answered "yes" if they thought the face was emotional and "no" if the face was not emotional. In Part 2, they rated each face stimulus on each of three scales (angriness, happiness, and emotionality). "Neutral" faces were not rated as quite neutral on the different scales. The d' values were higher for happy than for angry faces. When standardizing the d' values for each face type through division by its Euclidean distance from the "neutral" face in the scaled emotion space, a male superiority effect appeared for both happy and angry faces. Together with Pixtons' results, this suggests that when investigating the detectability of emotions, account must be taken of the particular stimuli used.

Extensive research has shown that the perception of emotional expressions is affected by many factors (e.g., emotional expression, gender of the face, gender of the perceiver, context, and stimulus quality). However, what seems to have been largely neglected is to what extent the particular stimulus set affects the results of facial perception studies (however see Purcell, Stewart, and Skov, 1996 for an example). For example, there are numerous findings that participants respond more quickly and more accurately to angry faces than to happy faces (e.g., Horstmann & Bauland, 2006). There are also reports showing that happy faces are detected more quickly and accurately than angry faces (e.g., Leppänen & Hietanen, 2004; Leppänen, Tenhunen, & Hietanen, 2003; Pixton, 2007). However, the potential effects of the particular stimuli have not discussed in these studies. For example, Leppänen et al. discussed the possibility that the advantage comes from the manner in which the stimuli are presented, rather than the difference between the stimulus subsets (i.e., happy and angry expressions). Leppänen and Hietanen discussed the saliency of the particular emotional expressions, but not the particular stimuli.

Pixton (2007) used signal detection analysis to test the manner in which shifts in sensitivity (*d'*) occur across presentation time, emotional expression, and gender of facial stimuli. Pixton reported a happy-superiority effect, but did not discuss the potential effect of the particular stimuli either. To investigate the potentially differential impact of the stimulus subsets, in a follow-up study, Pixton (2008) asked participants to rate each face stimulus used in the 2007 study on the three different scales *happiness*, *angriness*, and *emotionality*. Results from the scaling study showed that there was a greater distance on the relevant judgment continua between happy and neutral expressions than between angry and neutral expressions. These mean differences (*MD*s) were calculated for each emotion-gender face combination and used to standardize the *d'* values from the 2007 study. The results showed that as presentation

time increased, *d′* values increased as reported in 2007, but differently for the respective face combination. That is, whereas the results in 2007 showed higher *d′* values for happy faces, the results in 2008 showed equal Euclidean standardized *d′* values for all combinations except for the angry-female faces having lower values. Combined, these results suggest that detectability of emotional expressions depends on the particular stimulus set used. One potential problem with Pixton's (2008) results is that the original *d′* values and the *MD*s used to calculate the standardized *d′* values reported in 2008 are based on different groups of participants. Therefore, the purpose of the present study is to replicate and combine those two studies so that each participant performs both a signal detection task and a rating task.

Method

Participants. There were 30 (8 men, 22 women) psychology students ranging in age of 19 to 30 (M_{age} = 27.23). All participants gave informed written consent and had normal or corrected-to-normal visual acuity, which was controlled using the Bailey and Lovie (1976) LogMar 3-meter eye chart.

Stimuli and Apparatus. Ninety (30 angry, 30 happy, and 30 neutral) faces were used from the NimStim Set of Facial Expressions (Tottenham et al., 2009). For each emotion, there were 15 male and 15 female faces, the same poser for all emotions. The faces were closed-mouthed, in color, and included the entire face with hairstyles and without facial hair and eyeglasses. The pictures consisted of 500 x 650 pixels and were presented on a black background, measured at 0.35 cd/m^2. On the monitor, the pictures measured 12.3 x 16.0 cm, a viewing angle of 8.39° x 10.91° at a distance of 84 cm held constant by a chin rest.

The experiment was controlled by a Hewlett-Packard PC with a 21 in. ViewSonic® PerfectView™ CRT screen at 160 Hz, using Matlab 2006a with the Psychophysics Toolbox extensions (Brainard, 1997; Pelli, 1997). A 3-sided black viewing box with an opening for the monitor was used to help reduce reflections. Responses were made using a PC mouse.

Design and Procedure. The experiment consisted of one 75 minute session, which was divided into two parts: detection (approximately 45 min) and rating (approximately 30 min). The detection part of the experiment was designed as a yes-no experiment and the stimuli were presented across three exposure times (12.50, 18.75, and 25.00 ms) and were succeeded by a mask, which was presented for 125 ms.

First, each participant was individually tested for visual acuity, entered a quiet dimly-lit room, read written instructions, and signed consent forms. The participant was then given oral instructions and asked if there were any questions concerning the experiment. The participant then sat in front of the monitor where brief instructions appeared on the monitor, and the participant could start the experiment him- or herself when ready.

Each of the 30 neutral faces was presented four times and each of the 30 happy and 30 angry faces was presented twice for each of the three exposure times, giving a total of 720 trials. Participants were instructed to answer "yes" if the face was emotional and "no" if it was not emotional. Each trial consisted of either an angry face, a happy face, or a neutral face; a mask; and a 500 ms pause, after which the response alternatives appeared on the screen. The next trial began 500 ms after the participant had made a response. The participants were informed that an emotional face was to be defined by them and that there was no right or wrong answer. They were also told that it might be difficult to see the pictures, but should answer quickly and accurately in accordance to what they thought they saw.

In the second part of the experiment, the 90 pictures were presented individually in three blocks. Within each block, the participants rated each stimulus on angriness (Block A),

happiness (Block H), and emotionality (Block E). The rating scales for Block A and for Block H were 11-point scales (5 = *friendly*, 0 = *neutral*, 5 = *angry* and 5 = *sad*, 0 = *neutral*, 5 = *happy*, respectively). For Block E there was a 6-point scale (0 = *not at all emotional*, 5 = *very emotional*). The stimuli were presented pseudorandomly within each block, and block order was counter-balanced across participants. At the beginning of each block, instructions appeared on the monitor to inform the participants which block was beginning. Each trial consisted of one face and a scale below the face. After the participant had answered by clicking on a number in the scale, there was a 1-second inter-trial interval. Participants were asked to which degree each face displayed an emotion. They were instructed that the succeeding trial would not begin until they had responded; there was no time limit, but they should be as accurate as possible.

Results

Overall mean scale values were calculated for each emotion and gender of the face stimuli and their combinations in three blocks (see Table 1). The means were submitted as within-participant factors to a 2 x 3 x 3 (Gender [male and female] x Emotion [angry, neutral, and happy] x Block Type [angriness, happiness, emotionality]) repeated measures ANOVA (multivariate approach with Pillai tests) with sight and age as covariates. There were no significant effects of sight and age; thus, the analyses were conducted without these factors.

The main effect of gender was not significant ($p = .991$). There was a significant main effect of emotion, $F(2,28) = 276.18$, $p < .001$, $\eta_p^2 = .95$, with significant differences (Bonferonni adjusted) between each of the three emotional expressions (ps < .001). The main effect of block type was significant, $F(2,28) = 598.07$, $p < .001$, $\eta_p^2 = .97$, with significant differences between Block A and E ($p < .001$) and between Block H and E ($p < .001$), but not between Block A and H ($p = 1.000$).

There was a significant interaction between emotion and gender, $F(2,28) = 5.71$, $p = .008$, $\eta_p^2 = .29$, between gender and block type, $F(2,28) = 14.18$, $p < .001$, $\eta_p^2 = .50$, and between emotion and block type, $F(4,26) = 205.19$, $p < .001$, $\eta_p^2 = .97$. The triple interaction between gender, emotion, and block type was significant, $F(4,26) = 9.44$, $p < .001$, $\eta_p^2 = .59$.

Mean Difference Scale Values (*MD*). The mean difference scale values (*MD*) between each face type (see Table 2) were calculated and submitted to paired sample *t*-tests. The difference between the *MD*s of angry/neutral faces in Block A ($M = 2.84$) and H ($M = 3.46$) was significant, $t(29) = -3.60$, $p = .001$); there was a lesser distance between angry and neutral faces in Block A than between happy and neutral faces in Block H. Additionally, there was a difference between the overall ratings of neutral faces in Block A ($M = 0.16$) and in Block H ($M = -0.52$), $t(29) = 5.04$, $p < .001$, but not between angry faces in Block A ($M = 3.01$) and

Table 1. *Mean Scale Values (and Standard Deviations) for Emotion Face Types of Rated Emotional Expression and Perceived Emotionality in Three Block Types*

	Block Type		
Face Type	Block A: Angriness	Block H: Happiness	Block E: Emotionality
Happy-Female	-3.43 (0.73)	2.90 (0.67)	3.31 (0.63)
Happy-Male	-3.33 (0.67)	2.95 (0.66)	3.37 (0.55)
Angry-Female	3.03 (0.36)	-2.93 (1.07)	3.64 (1.07)
Angry-Male	2.76 (1.05)	-2.71 (1.13)	3.52 (0.71)
Neutral-Female	0.24 (0.35)	-0.61 (0.42)	0.75 (0.49)
Neutral-Male	0.04 (0.33)	-0.32 (0.43)	0.54 (0.52)

happy faces in Block H (M = 2.94) (p = .664). This shows that participants did not rate neutral faces similarly in Block A and H, but did rate angry faces in Block A similarly as happy faces in Block H. Interestingly, in a paired-sample t-test, male faces were rated as less angry than female faces, $t(29) = -2.63$, $p = .014$, in Block A and as less emotional than female faces, $t(29) = -2.65$, $p = .013$, in Block E, but as happier than female faces, $t(29) = 4.79$, $p < .001$, in Block H.

Mean Sensitivity (d'). Sensitivity (d'), which is the measure of ability to discriminate between target (emotion) and non-target (neutral) stimuli, was calculated as $d' = z(H) - z(F)$ (Macmillan & Creelman, 2005). H (hit rate) was the proportion of answering "yes" on emotional-face trials, F (false-alarm rate) was the proportion of answering "yes" on neutral-face trials, and z was the corresponding standard normal deviate.

The d' values (see Figure 1A) were then submitted to a 2 x 2 x 3 (Emotion [angry, happy] x Gender [male, female] x Presentation Time [12.50, 18.75, 25.00 ms]) repeated measures ANOVA (multivariate approach with Pillai tests) There was a significant main effect of emotion, $F(1,29) = 23.80$, $p < .001$, $\eta_p^2 = .45$, of gender, $F(1,29) = 24.30$, $p < .001$, $\eta_p^2 = .46$, and of time, $F(2,28) = 70.42$, $p < .001$, $\eta_p^2 = .92$. Male faces and happy faces had higher d' values than female faces and angry faces, respectively, and there was a significant difference between all presentation times ($p < .001$ for each comparison). There was a significant interaction between gender and emotion, $F(1,29) = 15.32$, $p = .001$, $\eta_p^2 = .35$, and between emotion and time, $F(2,28) = 26.76$, $p < .001$, $\eta_p^2 = .66$. There was neither an interaction between gender and time ($p = .056$), nor a triple-interaction ($p = .519$).

Post-hoc paired sample t-tests (with Bonferroni correction) for each face combination at each presentation time were performed. At 12.50 ms, there were only differences between angry-male and happy-male (p =.025) and angry-female (p =.036). At 18.75 ms, all face combination comparisons were significant (ps < .030), with the expectation for happy-male and happy-female faces (p = .068) and happy-female and angry-male (p = .950). All face combination comparisons were significant at 25.00 ms (ps < .040).

Euclidean Standardized d' (d'_E). The d' values for each participant were recalculated and standardized with the Euclidean distance (ED) for each participant between each of the emotional face types and their corresponding neutral face in the 3-dimensional space of Angriness, Happiness, and Emotionality (see Table 2). The EDs were calculated as $ED = (MD_{\text{Block A}}^2 + MD_{\text{Block H}}^2 + MD_{\text{Block E}}^2)^{1/2}$ and d'_Es were calculated as d'/ED for each block, facial emotion and gender, and presentation time.

As with the d' values, the d'_Es (see Figure 1B) were submitted to repeated measures ANOVA, and the results were similar. There was a significant main effect of gender, F(1,29)

Table 2. Mean Difference Scale Values (MD) of Rated Emotional Expression and Perceived Emotionality in Three Block Types and Euclidean Distance (ED) for Emotion Face Types

	Block Type			
Face Type	Block A: Angriness	Block H: Happiness	Block E: Emotionality	*Euclidean Distance*
Female				
Angry/Neutral	2.86	-2.20	2.93	*4.75*
Happy/Neutral	-3.66	3.62	2.48	*5.79*
Male				
Angry/Neutral	2.83	-2.35	3.12	*4.92*
Happy/Neutral	-3.41	3.31	2.88	*5.60*

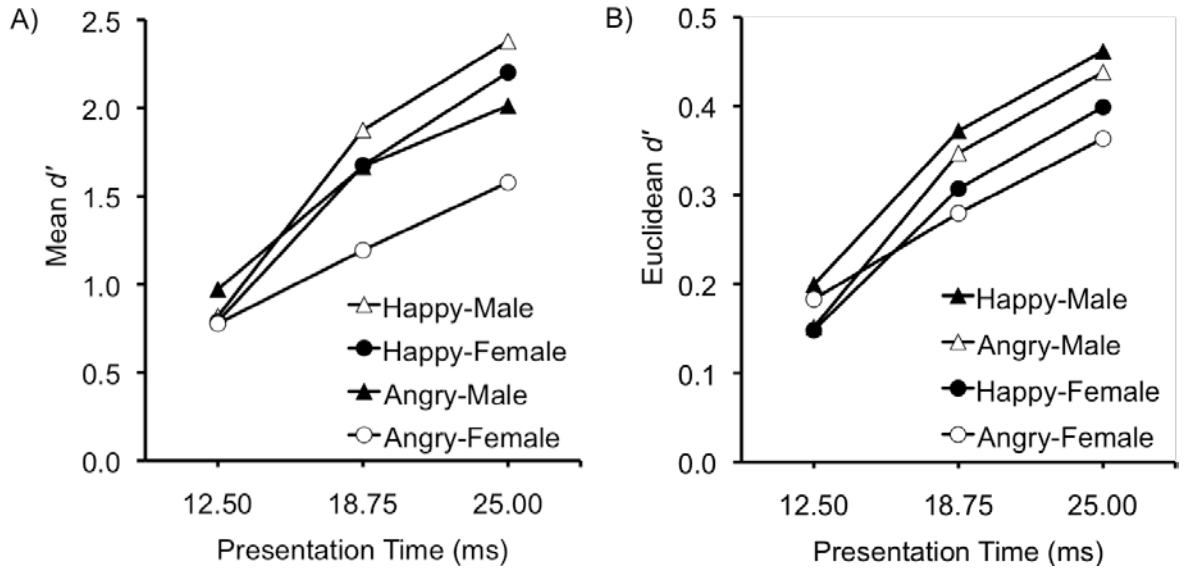

Figure 1. Mean *d'* (A) and Mean Euclidean Standardized *d'* (B) Values for Female and Male Emotional Faces Across Presentation Time in Milliseconds (ms).

= 14.68, $p = .001$, $\eta_p^2 = .34$, and time, $F(2,28) = 70.92$, $p < .001$, $\eta_p^2 = .84$; however, there was no effect of emotion ($p = .568$). Male faces had greater d'_E values than female faces ($p = .001$, Bonferroni adjustments), and there was a significant difference within each pair of presentation times ($p < .001$ for each comparison). There was a significant interaction between gender and emotion, $F(1,29) = 6.27$, $p = .018$, $\eta_p^2 = .18$, and between gender and time, $F(2,28) = 3.97$, $p = .030$, $\eta_p^2 = .22$, but not between emotion and time, ($p = .142$) or between emotion, gender, and time ($p = .281$).

The post-hoc *t*-tests (Bonferroni corrections) showed that the d'_Es shifted from the original *d'* values. At 12.25 ms, there were significant differences only between happy-female and angry-male ($p = .042$) and between happy-male and angry-male ($p = .014$). At 18.75 ms, there were significant differences between happy-female and angry-male ($p = .028$), angry-female and angry-male ($p = .001$), and angry-female and happy-male ($p = .032$). At 25.00 ms, all face combination comparisons were significant (ps < .024), except between happy-female and angry-male ($p = .091$), between happy-male and angry-male ($p = .028$) faces, and between happy-female and angry-female ($p = .508$) faces.

Discussion and Conclusion

The aim of the present study was to examine how the perceived emotional expression (as measured by *d'*) shifts in relation to a judgment task by comparing results from a detection task and a scaling task both completed by the same participant. This was done in order to replicate and combine the methods of Pixton's (2007, 2008) studies to overcome the potential confounder that the results came from two different samples.

The results of the present study indicate that presumably neutral facial stimuli may not be neutral. In line with suggestions by Russell and Fehr (1987) and Lee, Kang, Park, Kim, and An (2007), the results in the present study indicate that the neutral expressions were judged as being more towards angry when rating angriness and as being more towards sad when rating happiness. This suggests that the difference between happy and neutral is greater than the difference between angry and neutral expressions. Therefore, participants can discriminate happy from neutral face stimuli easier than they can discriminate angry from

neutral face stimuli, as reflected in higher *d*' values for happy faces than for angry faces. As found in Pixton's (2007, 2008) studies, the results from the present study indicate that sensitivity to emotional expressions is due to the judged intensity of the emotional expression of the stimuli.

After standardization of *d*', the happy-superiority advantage seems to have decreased, if not disappeared. There appears to be more of a male-superiority effect; as presentation time increased there was neither a difference between angry-female and happy-female faces, nor between angry-male and happy-male faces. This is different from the earlier results. In the 2008 results, the d'_Es for angry-female face stimuli remained lower than for the other stimuli. In the present study, the d'_Es were lower for female faces than for male faces, no matter the emotion. This indicates that there might not be a superiority effect of emotion, but a superiority effect of gender in that it was more difficult for participants to detect emotions in female faces than in male faces.

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