EXPECTING HAPPY WOMEN, NOT DETECTING THE ANGRY ONES

Detection and perceived intensity of facial anger, happiness, and emotionality

Tonya S. Pixton

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Expecting Happy Women, Not Detecting the Angry Ones

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Cover illustration by Henrik Halter (inspired by the little ones, making us happy)
Back cover portrait by Mats P. Englund (with frog, making me happy)

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To all those who put a smile on my face, joy in my heart, and happiness in my life...

Abstract

Faces provide cues for judgments regarding the emotional state of individuals. Using signal-detection methodology and a standardized stimulus set, the overall aim of the present dissertation was to investigate the detection of emotional facial expressions (i.e., angry and happy faces) with neutral expressions as the nontarget stimuli. Study I showed a happy-superiority effect and a bias towards reporting happiness in female faces. As work progressed, questions arose regarding whether the emotional stimuli were equal with regard to perceived strength of emotion, and whether the neutral faces were perceived as neutral. To further investigate the effect of stimulus quality on the obtained findings, Study II was designed such that the facial stimuli were rated on scales of happy-sad, angry-friendly, and emotionality. Results showed that 'neutral' facial expressions were not rated as neutral, and that there was a greater perceived distance between happy and neutral faces than between angry and neutral faces. These results were used to adjust the detectability measures to compensate for the varying distances of the angry and happy stimuli from the neutral stimuli in the emotional space. The happy-superiority effect was weakened, while an angry-female disadvantage remained. However, as these results were based upon different participant groups for detection and emotional rating, Study III was designed to investigate whether the results from Studies I and II could be replicated in a design where the same participants performed both tasks. Again, the results showed the non-neutrality of 'neutral' expressions and that happiness was more easily detected than anger, as shown in general emotion as well as specific emotion detection. Taken together, the overall results of the present dissertation demonstrate a happy-superiority effect that was greater for female than male faces, that angry-female faces were the most difficult to detect, and a bias to report female faces as happy.

Keywords: Signal Detection (Perception), Happiness, Anger, Face Perception, Facial Expressions, Superiority Effects, Gender Differences, Response Bias, Scaling, Euclidean Distance

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I am, indeed, a happy woman and hope to be perceived as so!!!

Life is good!

Tonya

List of Studies

The following studies are the basis of the present doctoral dissertation:

I Pixton, T. S. (in press). Happy to see me, aren't you, Sally? Signal detection analysis of emotion detection in briefly presented male and female faces. *Scandinavian Journal of Psychology*.*

II Pixton, T. S., Hellström, Å., Englund, M. P., & Larsson, M. (2011). The non-neutrality of 'neutral' faces: Effect on discriminability of emotional expressions. *Manuscript in preparation*.

III Pixton, T. S., Englund, M. P., & Hellström, Å. (2011). Are you emotional or simply happy? Detection and rated degree of anger, happiness, and emotionality in male and female faces. *Manuscript in preparation*.

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Abbreviations

Abbreviation	Full Reference
3D	Three-dimensional
d'	Sensitivity: *d* prime
ED	Euclidean Distance
FA	False-Alarm Rate
H	Hit Rate
MD	Mean Difference of Scale Value
MSV	Mean Scale Value
P	Probability
Scale A	Anger Scale
Scale E	Emotionality Scale
Scale H	Happiness Scale
SDT	Signal Detection Theory
β	Response Bias: Beta

Introduction

The matter of faces is one of great interest that has spanned the ages. As written by Shakespeare (1864/1989), "Your face, my thane, is a book where men may read strange matters" (Macbeth, Act I, Scene V). Humans have an exquisite ability to recognize faces, which is perfected from birth through one's lifetime. Everyone has had, at least, some experience with them and, most likely, has had many opinions regarding them. *Did you see the look on his face? I mean really, could she have looked anymore sour? Oh, what a happy woman, she smiles so! He's such a disagreeable person, he always looks so angry. Well, isn't he a jolly fellow, what a twinkle he has in his eye!!*

Hundreds of faces are seen everyday throughout one's lifetime and are a vast source of information. Faces provide individuals with many cues for judgments about other individuals or groups of individuals. Based on facial information, judgments are made regarding gender, age, familiarity, friend or foe, identity, and the emotional state of an individual, of which approximately six basic emotions have been identified (e.g., Darwin, 1872/1998; Ekman & Friesen, 1971). Accurate judgments of facial cues can be made with extremely brief exposures of faces, on the order of milliseconds (ms) (e.g., Kirouac & Doré, 1983, 1984), in which the extracted amount of information of the face is limited. These judgments are important in order to navigate and maneuver through the social world, adapting to the other's emotional states, as well as, eventually, protecting oneself from danger or, even better, maybe even forming a lasting friendship (Buss, 2004).

The face perception literature is vast, containing countless results on differences between men's and women's perception of emotion and gender of faces. That which seems to be consistent is that judgments of gender and emotion (and their combination) of a person from facial cues are made quickly and accurately (e.g., Atkinson, Tipples, Burt, & Young, 2005; Esteves & Öhman, 1993; Goos & Silverman, 2002; Grimshaw, Bulman-Fleming, & Ngo, 2004; Kirouac & Doré, 1984). Although there are numerous findings indicating that participants respond more quickly and more accurately to happy faces, there are also reports finding that angry faces are detected the most quickly and accurately (e.g., Horstmann & Bauland, 2006).

Upon closer inspection, it may appear that the difference of the two emotional expressions may be a matter of experimental method: Angry-superiority effects tend to be reported in studies where visual search methods have been used (e.g., Hansen & Hansen, 1988; Juth, Lundqvist, Karlsson, & Öhman, 2005; Öhman, Lundqvist, & Esteves, 2001; however, Öhman, Juth, and Lindqvist, 2010, regarding the generality of the angry-superiority effects in visual-search tasks), and happy-superiority effects tend to be reported in studies where there is a categorization of individual stimuli (e.g., Esteves & Öhman, 1993; Grimshaw et al., 2004; Kirouac & Doré, 1983, 1984; Leppänen & Hietanen, 2004, Milders, Sahraie, & Logan, 2008).

Together, the ability to extract information from briefly presented facial stimuli and the ongoing discussion of happy- and anger-superiority effects raised questions regarding whether signal detection methods have been used to investigate emotional facial expressions. One benefit, in particular, of using signal detection is that the sensitivity measure (*d*' in the present dissertation) is not only a measure of proportion correct. Indeed, the *d*' measure accounts for the source error of guessing or incorrectly perceiving *nontargets* (here, neutral facial expressions) as *targets* (here, angry or happy facial expressions), which is especially useful in situations in which there may be a high level of uncertainty (e.g., when stimuli are presented briefly, as is the present work). Also, signal detection offers the possibility of assessment of response bias, independently of detection performance, thus giving a picture of how the participants are responding, assessing whether they tend to answer *yes* more often than *no* or *no* more often than *yes*.

To the best of my knowledge only a few signal-detection studies (Goos & Silverman, 2002; Grimshaw et al., 2004; Milders et al., 2008) have included angry and happy faces, brief presentation times, gender of the face, and gender of the participant. Given the requirement of many trials in a signal detection experiment (Macmillan & Creelman, 2005; McNicol, 2005; and as mentioned by Esteves & Öhman, 1993), this gap in the literature is hardly surprising. Nevertheless, there is a gap in the literature, and, therefore, the studies that form the basis of this dissertation were designed to specifically address these factors within a signal detection framework. However, as the work on this dissertation progressed, focus shifted to include concerns regarding the stimulus set used (Tottenham, Tanaka, Leon et al., 2009) and whether the faces used (happy, angry, and neutral) are indeed rated as such. and whether the results that were obtained as the work progressed could be A further goal concerned whether the results could be replicated and validated (cf. Russell; 1994) in both a within-participant (detecting emotion, in general) and a between-groups design (detecting the specific emotion, anger or happiness).

Research Aims

The present dissertation is comprised of three consecutive experimental studies addressing discrimination of emotion in facial perception, specifically anger and happiness. Methodological concerns raised in Study I were followed up in Study II, which, in turn, formed the design of Study III.

The initial aim was to examine the effects of emotional facial expressions (i.e., anger and happiness), the gender of the stimulus faces, and the gender of the participant on sensitivity (d') and response bias (β) (Study I). As this work progressed, questions arose regarding whether there might be a built-in methodological problem with the design of using happy versus neutral and angry versus neutral faces within a signal detection paradigm. Specifically, questions remained regarding whether the stimuli from the standardized stimulus set (Tottenham et al., 2009) were equal with regard to perceived strength of emotion (anger vs. happiness), and whether the neutral faces were indeed perceived as neutral. If, for example, the neutral faces were not neutral but closer to, for example, angry faces, this could cause an apparent happy-superiority effect.

Although the face stimuli were chosen with regard to their rated validity on the specific emotional category, the results indicated that the neutral facial stimuli were, in fact, not rated as neutral, but deviated from the midpoints on bipolar rating scales of happy-sad and angry-friendly (Study II). As these methodological concerns were addressed post-hoc, hypotheses were posed regarding whether the same results would emerge when asking the participant to detect emotion, as well as rate the emotional and 'neutral' stimuli (Study III). Also, further questions were raised regarding whether similar results would emerge if participants were asked to detect the specific emotion (angry or happy), as well as completing the rating task (Study III). Formally, the specific aims of the present dissertation were:

1. *Study I:* To examine the detectability (i.e., sensitivity, d') and response bias (β) of emotion in anger and happy male and female faces using a signal detection paradigm. A secondary aim was to examine whether sensitivity and response bias are influenced by gender-of-participant, gender-of-face, and presentation time.
2. *Study II*: To examine whether 'neutral' faces are perceived as neutral when judged on three different scales of Anger (Scale A),

Happiness (Scale H), and Emotionality (Scale E). A secondary aim was to examine whether the sensitivity values reported in Study I would be modified when adjusting for a potential greater difference in rated intensity between happy and neutral than between angry and neutral facial expressions by calculating the perceived intensity of the angry, happy, and neutral facial expressions used in Study I.

3. *Study III, Experiment 1*: To examine whether the combined results found in Studies I and II could be replicated using a within-participant design where each participant completed both a signal-detection task for emotion (cf. Study I) and an emotion-rating task (cf. Study II).
4. *Study III, Experiment 2*: To examine whether the happy-superiority effect found in Studies I and III, Experiment 1, could be replicated using a between-groups design with one group detecting anger and another group detecting happiness.

Happy to See Me, Aren't You?

Quick detection of and response to facial cues are not without obstacles, and emotional expressions are not detected without interferences. For example, emotional expressions are embedded within all types of facial cues, such as those that signal gender, identity, and age. Evidence indicates that emotion is processed more quickly than other facial cues. For example, in a series of experiments, Esteves and Öhman (1993) examined the effects of backward masking with stimulus onset asymmetries (SOAs) in detecting facial emotions. Not only was their purpose to vary the duration of the SOAs but also to compare recognition responses of gender and identity. Threshold levels were lower (i.e., required presentation times were shorter) for emotion than for gender- and identity-of-face, and, interestingly, threshold levels were lower for happy than for angry and neutral faces.

Anger- and Happy-Superiority Effects

As noted by Leppänen and Hietanen (2004), the results regarding happy- or anger-superiority effects should be evaluated in the light of the experimental methods used. In visual search studies, an anger-superiority effect has been reported, where threatening stimuli (i.e., angry faces) are distinguished more efficiently than nonthreatening stimuli (i.e., happy faces). Evidence from such tasks shows that angry faces are distinguished more quickly and with greater accuracy than happy faces (e.g., Hansen & Hansen, 1988; Juth et al., 2005; Öhman et al., 2001). This is in line with an evolutionary perspective suggesting that the ability to detect quickly and respond to a potential threat (e.g., an angry facial expression) has an important survival value.

The results in support of an angry-superiority effect should, however, be interpreted with caution, as not all visual search task studies show a straightforward angry-superiority effect. It has been suggested (Hampton, Purcell, Bersine, Hansen, & Hansen, 1989) that the angry-superiority effect may be a by-product of a quicker search through the happy face crowd to find the angry face, as compared to searching through the angry face crowd to find the happy face. The authors also suggest that the position of the discrepant face in the crowd may affect the results. In contrast, a happy-superiority effect is observed when real faces rather than schematic faces are used as stimuli (Calvo & Nummenmaa, 2008; Juth et al. 2005; Öhman et al., 2010).

Furthermore, there is evidence that there may be an effect of over-familiarity of the stimuli, which may improve the performance in depicting the discrepant face in the crowd. As Öhman et al. (2010) reported, when the stimulus set is large, a happy-superiority effect emerges; when the stimulus set is small, an angry-superiority effect emerges. Hence, when using schematic faces, an anger-superiority effect may emerge as there is a small range of stimuli that can be used, as compared to a real-face stimulus set. Taken together, these findings suggest that, at least for visual search tasks, evidence is mixed regarding a happy-superiority or anger-superiority effect.

In recognition studies, there are indications that participants respond more quickly and more accurately to happy faces than to faces displaying other emotions, and the evidence here seems to be more consistent (e.g., Esteves & Öhman, 1993; Grimshaw et al., 2004; Kirouac & Doré, 1983, 1984; Leppänen & Hietanen, 2004; Milders et al., 2008). For example, Kirouac and Doré (1983, 1984) investigated accuracy and latency of response in a categorization task with six emotions (happiness, sadness, disgust, anger, surprise, and fear). Generally, there were more correct responses for happiness and for surprise as compared to the other emotions, and there were shorter response latencies for happiness than for the other emotions. Kirouac and Doré (1984) examined accuracy in categorizing happiness, surprise, fear, disgust, anger, and sadness as a function of stimulus presentation time (10, 20, 30, 40, & 50 ms), and found that participants were able to classify happiness more correctly compared to the other emotions, even at presentation times as brief as 10 and 20 ms. Furthermore, Kirouac and Doré also found a gender-of-participant effect in that women were more accurate than men for each emotion, but this effect accounted for a lower proportion of the variance than did the effect of the type of emotional expression.

In such recognition tasks, there is generally a one-stimulus presentation, which is to be categorized (classified) as a particular emotion. Therefore, scanning of that stimulus may be more detailed in a recognition task than in a visual search task where there may be a quicker scanning of the many stimuli that are presented (Leppänen & Hietanen, 2004). Thus, the more consistent happy-superiority effect in recognition tasks may reflect a "higher-level asymmetry in the recognition of emotionally positive and negative signals" (Leppänen & Hietanen, 2004, p. 27). It may also reflect a tendency for humans to be drawn towards positive information (Grinde, 2002), potentially being driven by some kind of evolutionary pleasure-seeking mechanism, avoiding threat and approaching tenderness is more rewarding in that warm and friendliness may increase attractiveness (Mehu, Little, & Dunbar, 2008) and thus draw the attention of a potential partner.

Signal Detection Theory

One does not perceive the world around oneself without distractions. One is constantly bombarded with information from the environment, and must make decisions based on uncertain information about what may or may not have seen, heard, or felt in a not so perfect world. A benefit of using signal detection theory (SDT) is that it yields a good measure of the ability to discriminate between stimuli in situations of uncertainty, for example, when stimuli are presented briefly (as in the present dissertation).

SDT is a theory that yields measures of the ability to discriminate a given stimulus from another (for reviews, see Green and Swets, 1966; Macmillan & Creelman, 2005; McNicol, 2005). According to signal detection theory, in a dichotomous detection task, as in the present work, both a signal (*target*, defined as signal + noise) and the nonsignal (*nontarget*, defined as noise) are distributed on an internal decision continuum (see Figure 1). To exemplify from the present dissertation, participants were to detect emotion or not (Study I & Study III, Experiment 1), anger or not (Study III, Experiment 2), or happiness or not (Study III, Experiment 2). Therefore, *targets* were the happy and angry facial expressions, and the *nontargets* were the neutral facial expressions. The ability to detect *targets* among *nontargets* is measured by sensitivity, *d'* (Macmillan & Creelman, 2005).

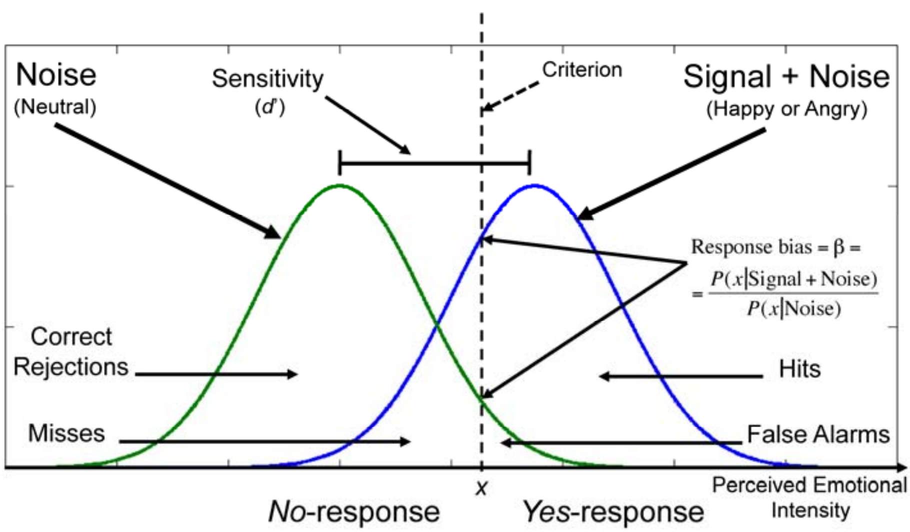

Figure 1. The normal distributions of noise and signal + noise along the decision continuum with sensitivity, the criterion point at which one answers *yes* or *no*, and response bias measures for Signal Detection Theory (SDT) in relation to the present dissertation.

Also, the SDT paradigm yields a measure of response bias based on the likelihood of occurrence of the *target* over the *nontarget*. Whenever this likelihood is above a criterion point, β, the participant will report the presence of a *target* (angry, happy) and otherwise a *nontarget* (neutral). The manner in which the participant answers or, rather, the tendency of the participant favoring one response over another is thus measured by β (Macmillan & Creelman, 2005).

Sensitivity (*d*')

Sensitivity is the measure of discrimination that is the difference between the standard normal deviates (*z*-values) corresponding to the proportions of *yes*-responses to the presented *targets* (hits; i.e., true positive responses) and to the presented *nontargets* (false alarms; i.e., false positive responses), respectively (a stimulus-response matrix of SDT is presented in Table 1). The higher the sensitivity, the better the participant can discriminate between the *target* and *nontarget* stimuli (for present purposes, angry and happy versus neutral facial expressions, respectively).

The *d*' measure is especially useful in situations with high levels of uncertainty, as in recognition experiments where brief presentation times are normally used, as in the present dissertation. In these situations, participants may be more likely to guess or incorrectly perceive *nontargets* as *targets*, and this source of error is taken into consideration by using the *d*' measure. In contrast to performance measures based only on proportion of hits, *d*' takes false alarms into account.[1] Furthermore, *d*' is a useful measure of discrimination performance that is invariant when response bias shifts (Macmillan & Creelman, 2005).

Table 1. *A Stimulus-Response Matrix of the Terminology Used in Signal Detection Theory (SDT) in Relation to the Present Dissertation*

Response	Signal + Noise (Happy, Angry)	Noise (Neutral)
Yes, The Face is Emotional, Happy, or Angry	Hit (H)	False Alarm (FA)
No, The Face is Not Emotional, Happy, or Angry	Miss (M)	Correct Rejection (CR)

[1] Attempting to take false alarms into account by simply forming a discrimination measure by subtracting percent false alarms from percent hits implies the assumption of rectangular distributions, which is unlikely to be justified.

This measure of discrimination is a mathematical representation of the perceptual difference between stimuli. In discriminating two stimuli, the perceptual distance between them is, therefore, positive. Thus *d*' should not be negative; however, a negative score can occur at chance level performance (which also may be considered a floor effect) or when the experiment has been designed with few trials. Thus, to avoid potential floor effects, Studies I and III were designed with approximately 500 trials for each of five presentation times.

Not only does *d*' have a *positivity* property; it also has an *unboundedness* property, meaning that there is no maximum value for *d*' (Macmillan & Creelman, 2005). Large *d*' values can occur when the discrimination of the stimuli is too easy, which can lead to potential ceiling effects. Corrections can be made to help adjust for such effects; proportions of *hit* and *false alarm* rates of 0 and 1 can be calculated as $1/(2N)$ and $1 - 1/(2N)$, respectively, where N is the number of trials per condition.

Response Bias (β)

One important benefit of using SDT is that it enables the assessment of the response style of the participant, independent of the discrimination performance. The response style is formally regarded as response bias (measured by beta, β); this measure estimates the likelihood ratio of *target* to *nontarget* (here, angry or happy to neutral) that the participant uses as his or her criterion for answering *yes*. That is, β is the participant's decision criterion (Macmillan & Creelman, 2005).

A β value of one indicates that the participant has a neutral or unbiased response style and, thus, favoring neither yes nor no answers. Beta values differing from one indicate the presence of response bias: A beta value below one indicates a liberal answering style, responding *yes* more readily than *no*, whereas a value above one indicates a conservative or strict answering style, answering *no* more readily than *yes*. Thus, β gives an understanding of the manner with which the participant weighs the evidence for and against in selecting the answer – *yes* or *no* – emotional (angry and happy faces) or not emotional (neutral faces).

As discussed by Esteves and Öhman (1993), a benefit of SDT is that the manner in which the participant is answering can be distinguished from detection sensitivity. Because there seem to be only few studies that have taken into β consideration, and the results have been mixed (e.g., Heuer, Lange, Isaac, Rinck, & Becker, 2010; Leppänen & Hietanen, 2004), one aspect of the present dissertation was to investigate in what manner participants are answering and whether there would be a favoring of one or more face type(s). Specifically, whereas Heuer et al. (2010) found a response bias, favoring happy faces, Leppänen and Hietanen (2004) did not find any favoring happy or angry over the other. The further investigation of potential response bias is important, though, because such a bias may have increased happy-superiority effects in studies in which emotion discrimination have been measured as percent correct. Furthermore, although a happy-superiority effect is often found, especially in recognition/categorization tasks, interpreting these results as showing a true superiority effect may not be warranted. For example, as found by Ekman (1982), Hansen and Hansen (1988), and Esteves and Öhman (1993), participants often confused neutral and angry faces; therefore, any type of superiority effect may be misleading if consideration is not taken regarding whether participants are favoring answering *yes* or *no*.

Gender Differences

Discriminating between male and female faces is considered to be one of the most accurate abilities in face perception (Burton, Bruce, & Dench, 1993) with high accuracy of gender categorization as young as 9 months of age (Fagot & Leinbach, 1993), and evidence suggests that both the gender of the facial stimuli and the gender of the perceiver affect the detection of emotional faces. Although Esteves and Öhman (1993) showed that emotion recognition was better than that of gender, Bruce, Burton, Hanna et al. (1993) found that participants could discriminate facial gender with about 85% accuracy, and that the eyes carry most of the information about facial gender cues (e.g., Brown & Perrett, 1993; Roberts & Bruce, 1988). Furthermore, this accuracy in categorizing faces as male or female is generally stronger for female than for male participants (e.g., Herlitz, Nilsson, & Bäckman, 1997; Rehnman & Herlitz, 2007; Shapiro & Penrod, 1986).

Gender of the face

In a verbal emotion categorization task, Goos and Silverman (2002) asked participants to view emotional faces for 30 ms and to classify the expression (anger, disgust, fear, or sadness) that had been presented. Goos and Silverman (2002) found that participants more often reported expressions of anger and disgust incorrectly in male than in female faces, and expressions of fear and sadness in female than in male faces. The authors, therefore, suggested that male faces are more apt to be perceived as angry or disgusted, and female faces are more apt to be perceived as fearful or sad.

Becker, Kenrick, Neuberg, Blackwell, and Smith (2007) found that participants responded more quickly to angry-male faces than to angry-female faces and to happy-female faces than to happy-male faces. Therefore, Becker et al. (2007) concluded that gender and emotional expression in face stimuli may not be processed independently, which was also suggested by Le Gal and Bruce (2002).

Dependence between gender and perceived emotional expression may be due to a stereotyped expectation of viewers that male faces will express more threatening emotions whereas female faces may be expected to express more warm and positive emotions (Hess, Adams, & Kleck, 2004). A gender stereotype may be reasonably supported by the expected social roles of men and women; men are expected to be found in more dominant roles and women in more nurturing roles. Thus, a male face may be readily perceived as expressing anger and a female face as expressing happiness (e.g., Hess, Adams, Grammer, & Kleck, 2009), reflecting a type of social expectation of the genders in emotional expression (e.g., Plant, Hyde, Keltner, & Devine, 2000).

Additionally, the markers that signal dominance and anger (e.g., Zebrowitz, 1997), for example, thicker eyebrows, are also those that signal maleness (e.g., Brown & Perrett, 1993; Burton et al., 1993). A marker that signals femaleness is a rounded baby-face appearance (e.g., Brown & Perrett, 1993; Burton et al., 1993), which also signals warmth and friendliness. It may, therefore, be as suggested by Becker et al. (2007) that the features that cue anger and happiness have evolved to signal also maleness and femaleness, respectively.

Gender of the participant

Not only does it appear that the facial gender of the stimuli plays a role in the perception and processing of emotional faces, observations also indicate effects of the gender of the participant, often favoring women (e.g., Goos & Silverman, 2002; Hall, 1978; Hall & Matsumoto, 2004; Montagne, Kessels, Frigerio, de Haan, & Perrett, 2005). Research suggests that women are better than men at decoding emotional expressions in faces (e.g., Hall, 1978; Hall & Matsumoto, 2004; see McClure, 2000 for a review). There is also evidence that women remember faces better than men (e.g., Rehnman & Herlitz, 2007; Wahlin, Bäckman, Mäntylä, Herlitz, Viitanen, & Winblad, 1993), and this effect is greater for female faces (Lewin & Herlitz, 2002). This observation is congruent with research indicating a general female superiority in processing episodic memory information (Herlitz et al., 1997).

In addition to investigating facial gender, Goos and Silverman (2002) found a difference in performance between male and female participants, where women categorized emotional expressions better (as measured by d') than men, and specifically anger and sadness better in female than in male faces. The authors explained their results in terms of an evolutionary perspective; women are more vulnerable to threat than men and therefore have a heightened response to those cues that signal threat (i.e., angry facial expressions). This may further reflect that women's lesser physical strength than men's has required women to develop a better ability to decode facial emotional signals in order to avoid threatening situations (e.g., Geary, 1998).

Similarly, Grimshaw et al. (2004) analyzed differences between men and women and the perception of emotional facial expressions in terms of SDT. They tested whether participant-gender differences would emerge with decreased presentation times, thus with reduced amounts of information presented to the participants. They found no such participant-gender effects, and, therefore, suggested that the participant-gender differences found in the literature on the perception of emotion may be due to the methodology of the experiment.

Also, it has been proposed that women and men may have different response styles, in terms of response bias (Sasson, Pinkham, Richard, Hughett, Gur, & Gur, 2010). Sasson et al. (2010) reported that women tended to have a response bias towards answering that an emotional facial expression is fearful or sad, whereas men tended to respond that an emotional facial expression was angry, fearful, or sad, rather than happy. Thus, Sasson et al. (2010) demonstrated that there might be, indeed, a gender-of-participant effect in answering style (response bias). However, a gender difference in response bias seems not to be readily found in the literature on facial emotional expressions. With this said, however, it should be noted that Leppänen och Hietanen (2004) examined whether there was a response bias towards a particular emotional expression. They did not find such a response bias. However, one of the aims of Study I was to investigate whether there is such a response bias and whether there is a difference between how men and women respond to particular emotional expressions (i.e., anger, happiness).

Previous Signal Detection Studies

A review of the literature shows that SDT has been sparsely used in the examination of facial emotion expression discrimination, which may in part be due to such a high demand of data points per condition, as mentioned by Esteves and Öhman (1993), which in the case of the present dissertation was fulfilled. Although there are studies that have investigated emotional face perception using SDT (e.g., Goos & Silverman, 2002; Grimshaw et al., 2004; Milders et al., 2008), it appears that all of the variables that are considered in the present dissertation (emotion-of face, gender-of-face, gender-of-participant, and brief presentation times) have not been combined into one study. As mentioned previously, Goos and Silverman (2002) asked participants to view emotional faces for 30 ms only and to classify the expression (anger, disgust, fear, or sadness) that had been presented. The study did not include positive facial expressions implicating that a potential happy-superiority effect could not be evaluated.

However, Grimshaw et al. (2004) built upon Goos and Silverman’s (2002) results and measured sensitivity (*d*') and response times in the recognition of happy, sad, and angry facial expressions. Participants had higher sensitivity with fewer false alarms and responded more quickly to happy faces than to sad and angry faces. The results are based on responses made at 50 ms and may have yielded ceiling effects as shown by relatively high *d*' values, ranging between 2.43 and 3.53 (Macmillan & Creelman, 2005).

Similar results were found by Milders et al. (2008). The authors reported that participants had higher sensitivity (as measured by *A*', a nonparametric alternative to *d*') for happy than to angry, fearful, and neutral faces in an emotion categorization task. Participants reported awareness of happy facial expressions presented at 10 ms and of angry and fearful expressions at 20 ms. However, the happy-superiority effect may have been a product of confusion between angry and fearful expressions. Both angry and fearful facial expressions signal threat, high arousal, and negative pleasure (e.g., Russell & Fehr, 1987), and may therefore be more easily confused with each other than with happy expressions. A potential confusion between angry and fearful may have produced more incorrect responses for these expressions than for happy expressions, resulting in a comparatively lower sensitivity for the angry and fearful expressions.

Based on previous evidence presented above, Study 1 was planned to address emotional face detection as a function of facial gender, gender-of-participant, and presentation times using a signal detection framework.

Overview of Study I

Pixton, T. S. (in press). Happy to see me, aren't you, Sally? Signal detection analysis of emotion detection in briefly presented male and female faces. *Scandinavian Journal of Psychology.*

Aims

The main aim of Study I was to examine emotional facial detection using a signal-detection paradigm and investigate whether a possible superiority effect may be due to a bias toward reporting a particular emotion, in particular happiness or anger. Secondary aims were to examine the detectability (i.e., sensitivity, *d*') and response bias (β) of anger and happiness in male and female faces using a signal detection paradigm. A further aim was to examine whether sensitivity and response bias is influenced by gender-of-participant, gender-of-face, and presentation time.

Background

The main purpose of Study I was not to resolve the question of whether the anger- or the happy-superiority effect takes precedence, but rather to extend upon the signal detection research on facial expressions, regarding happy and angry expressions. Although there is an extensive body of research regarding facial expression detection, including anger versus happiness, as well as gender-of-face effects, there seem to be only few signal detection studies addressing the effects of each of the variables of gender-of-face, gender-of-participant, emotion-of-face, and presentation time upon sensitivity within the same study. Additionally, to the best of my knowledge, no signal detection study of facial emotion has reported results on response bias.

Another aim of Study I was to examine the detection (i.e., sensitivity, *d*') and response bias (β) of anger and happiness in male and female faces in a signal detection paradigm. A secondary aim was to examine whether sensitivity and response bias were influenced by gender-of-participant, facial gender, and presentation times (6.25, 12.50, 18.75, 25.00, 31.25 ms).

Based on previous evidence, a general happy-superiority effect was expected, in terms of *d'*, as well as an angry-male superiority effect. Also, β values were expected to be lower for happy than for angry faces. Previous evidence (e.g., Sasson et al., 2010) suggests that there may be an effect of gender-of-participant on response bias. Therefore, if, indeed a gender effect was found, it was expected that female participants would exhibit lower overall β values than male participants.

Method

There were 57 undergraduate and graduate students (28 men, 29 women; no difference in age or visual acuity, which was measured on the LogMar eyechart; Bailey & Lovie, 1976). The participants individually viewed 90 colored closed-mouth faces of 15 men and 15 women, each expressing anger, happiness, and neutrality (Tottenham et al., 2009)[2]. The faces were presented pseudorandomly across five different presentation times (6.25, 12.50, 18.75, 25.00, 31.25 ms)[3] and controlled by Matlab software with the Psychophysics Toolbox (Brainard, 1997; Pelli, 1997). Each face was presented twice for each presentation time across four different sessions (two sessions for the angry-neutral set and two sessions for the happy-neutral set), with two different session orders (happy-angry-happy-angry, angry-happy-angry-happy). Each session lasted for approximately 40 minutes. There were 600 trials for each session and 2400 trials in total.

The participant's task was to respond whether she or he thought the face that was presented was emotional or not. He or she was to respond *yes* if the face was emotional and *no* if the face was not emotional. The participant

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[2] The stimulus subset from the NimStim set for the present dissertation included faces with mixed racial background. However, upon closer investigation, the mean reliability of the judgments from Tottenham et al. (2009) showed no differences in the mean reliability scores due to gender and ethnicity. There was a slight significant difference between angry and neutral faces only ($p = 0.046$); neutral faces had slightly higher reliability scores then angry faces. There were no other significant main effects or interactions; therefore, the stimuli were considered appropriate for use.

[3] Notably, the initial presentation times were set to 25.00, 31.25, 37.50, 43.75, and 50.00 ms and were used with a different participant group than whose data is presented in the present study. These times were chosen in part based on previous work indicating that at 30 ms gender-of-participant differences have been found (Goos & Silverman, 2002) but not at 50 ms (Grimshaw et al., 2004). Also, these times where chosen to encompass 30 ms, which is the time that seems to prevent conscious processing of the stimuli where there is limited information available to the participant (e.g., Esteves, Parra, Dimberg, & Öhman, 1994). However, results revealed near-perfect performance and exposure times were shortened as to encompass the briefest exposure time (10 ms) used by Kirouac and Doré (1984) and Milders et al. (2008) and in order to avoid ceiling effects (Macmillan & Creelman, 2005; Wiens, Peira, Golkar, & Öhman, 2008), which were obtained by Grimshaw et al. (2004).

made a response with a computer mouse by clicking on response alternatives that were presented on the monitor after each face stimulus was displayed.

The hit rate [*P*(*H*), the proportion (*P*) of *yes*-responses on emotional-face trials (angry or happy faces)], and the false alarm rate [*P*(*FA*), the proportion (*P*) of *yes*-responses on neutral-face trials], were calculated for each condition (gender-of-face, emotion-of-face, and presentation time). Sensitivity (d'), which is the measure of ability to discriminate between *target* and *non-target* stimuli, and response bias (β), a measure of response tendency, were then calculated as $d' = z(H) - z(FA)$ and $\beta = e^{(c \cdot d')}$, respectively, where $c = (-1/2) \cdot [z(H) + z(FA)]$ (Macmillan & Creelman, 2005).[4]

Results

The mean values for each emotion-gender face combination were calculated for d' and β (see Table 2). The d' and β values were then submitted separately to a 2 x 2 x 5 (Emotion [angry, happy] x Gender-of-Face [female, male] x Time [6.25, 12.50, 18.75, 25.00, 31.25 ms]) repeated-measures ANOVA. Analyses of linear trends (Laija, 1997) and simple analyses (Howell, 2002) were also conducted. Initial analyses showed that there were neither gender-of-participant effects nor session-order effects; therefore, subsequent analyses were conducted disregarding these factors.[5]

[4] The β value is the likelihood ratio used as the response criterion and gives a clearer understanding of the shifts in criterion bias (Macmillan & Creelman, 2005) than the *c* value (the threshold point on the subjective continuum at which the participant chooses to respond *yes*) which is often used in the literature; therefore, *c* is not considered in Studies I, II, or III. It can be calculated as $c = (\ln \beta)/d'$.

[5] Because participants viewed the same neutral faces in both the angry and happy conditions, analyses were performed to control for possible familiarity effects on the neutral facial expressions. Two separate 2 x 2 x 5 (Session: [1 and 3 or 2 and 4] x Gender-of-Face [female, male] x Time [6.25, 12.50, 18.75, 25.00, 31.25 ms]) mixed measures ANOVAs were conducted with order (session order AHAH or HAHA) as a between-subject factor. Results from this analysis for Sessions 1 and 3 showed a main effect of session, $F(1,55) = 11.36$, $p = .001$, $\eta_p^2 = .17$; there were higher d' values for Session 3 ($M = 1.22$) than for Session 1 ($M = 1.08$), indicating a learning effect for the participants. Most importantly, however, there was no significant difference between the orders, and the interaction between session and order was not significant ($p = .123$). Thus, the two emotion-groups' performances improved equally from Session 1 to Session 3. For Sessions 2 and 4, the results were similar; there was a significant main effect of session, $F(1,55) = 6.62$, $p = .013$, $\eta_p^2 = .11$, with higher d' values for Session 4 ($M = 1.25$) than for Session 2 ($M = 1.15$). There was no significant difference between the orders, and no significant interaction of Session x Emotion-group ($p = .375$) indicating that the two orders improved their performance to a similar extent.

Table 2. *Mean Values (M) and Standard Deviations (SD) of Sensitivity (d') for Emotion- and Gender-of-Face Types for Each Presentation Time*

	Presentation Time (ms)									
	6.25		12.50		18.75		25.00		31.25	
Face Type	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
					d'					
Happy	0.08	0.21	0.70	0.62	1.67	0.98	2.19	1.07	2.48	1.02
Angry	0.04	0.21	0.62	0.48	1.10	0.63	1.42	0.69	1.61	0.74
Male	0.04	0.19	0.64	0.53	1.44	0.82	1.91	0.86	2.19	0.88
Female	0.09	0.25	0.69	0.54	1.33	0.72	1.69	0.83	1.91	0.79
Overall	0.06	0.16	0.66	0.51	1.38	0.76	1.80	0.83	2.05	0.82
					β					
Happy	1.27	0.51	1.51	1.30	1.36	1.27	1.17	1.34	0.89	1.09
Angry	1.19	0.47	1.52	0.91	1.34	0.76	1.58	1.60	1.52	1.38
Male	1.15	0.31	1.51	1.01	1.43	1.07	1.63	1.73	1.40	1.49
Female	1.31	0.67	1.53	1.17	1.27	0.98	1.14	1.00	1.01	0.83
Overall	1.23	0.40	1.04	1.52	1.35	0.94	1.38	1.27	1.21	1.12

Analyses showed that *d*' values were higher for male than for female faces, higher for happy than for angry faces, and became higher with increasing presentation time (see Figure 2). With longer presentation time, *d*' values increased more for happy than for angry faces, which supports a happy-superiority effect. This latter effect is greater for male than for female faces, such that there is a greater difference in *d*' between happy- and angry-female faces than between happy- and angry-male faces. Furthermore, the increase in *d*' values was less pronounced for angry-female faces than for the other emotional face types.

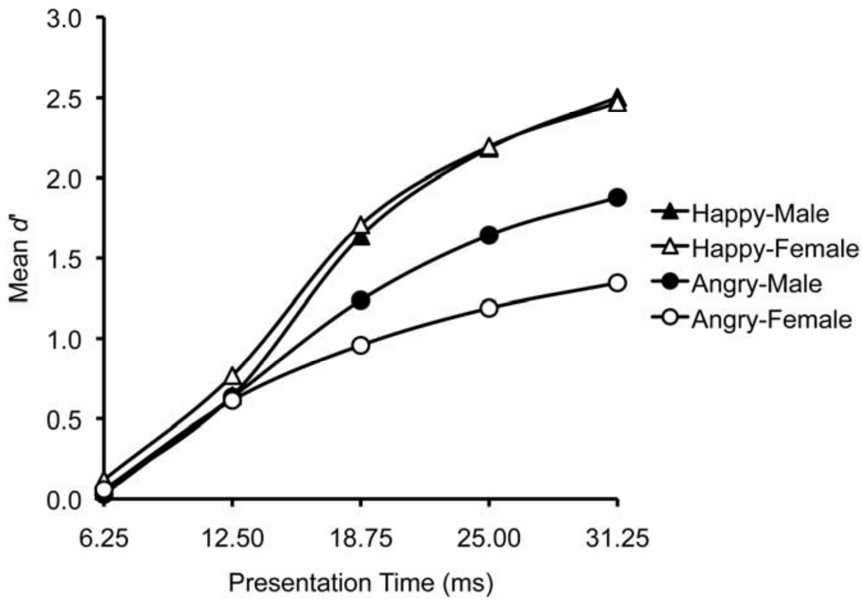

Figure 2. Mean sensitivity (*d*') for each emotion-gender face combination at five presentation times. (From "Happy to see Me, Aren't You, Sally? Signal detection analysis of emotion detection in briefly presented male and female faces," Pixton, *Scandinavian Journal of Psychology*, in press, Copyright [2011], John Wiley & Sons, Inc. Reprinted with permission from The Psychological Associations of Denmark, Finland, Norway and Sweden and Wiley-Blackwell.)

As shown in Figure 3, there were higher β values for angry than for happy faces and higher values for male than for female faces, which indicated that angry faces and male faces had a lower tendency to be reported as emotional than happy faces and female faces. There was, however, no interaction between emotion and gender of the face. Further analyses showed that at presentation times longer than 12.50 ms, happy-female faces had significantly lower β values than the other emotion-gender face combinations, which indicated a bias to report happy-female faces as emotional. Also, the β values for angry-female, angry-male, and happy-male faces remained relatively constant with increasing presentation time.

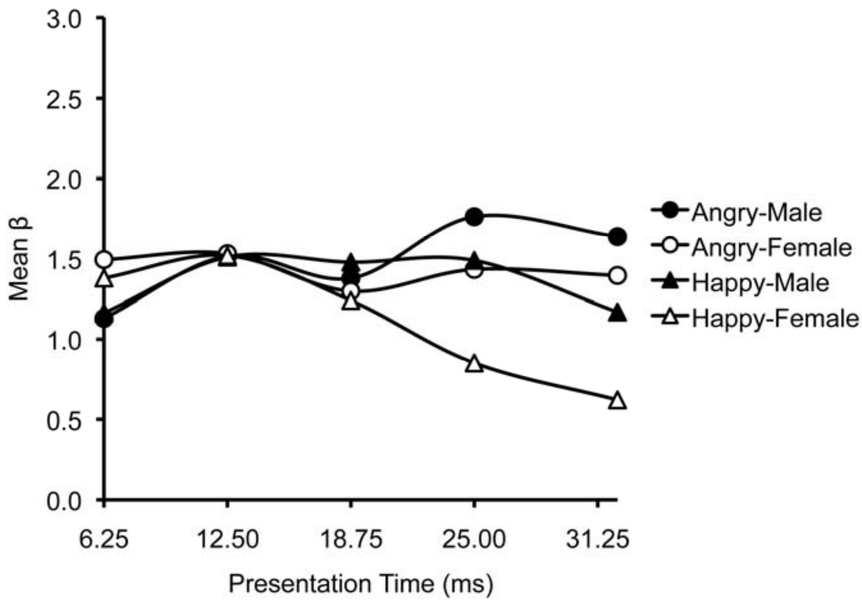

Figure 3. Mean response bias (β) for each emotion-gender face combination at five presentation times. (From "Happy to see Me, Aren't You, Sally? Signal detection analysis of emotion detection in briefly presented male and female faces," Pixton, *Scandinavian Journal of Psychology*, in press, Copyright [2011], John Wiley & Sons, Inc. Reprinted with permission from The Psychological Associations of Denmark, Finland, Norway and Sweden and Wiley-Blackwell.)

Conclusions

In general, regardless of the gender of the participant, emotion was detected more easily in happy faces than in angry faces, demonstrating a happy-superiority effect. Although there was no effect of facial gender for happy faces, there was such an effect for angry faces, as it was more difficult to detect emotion in angry-female faces than in angry-male faces. Interestingly, there were no effects of gender-of-participant on either emotion sensitivity or response bias, suggesting that perhaps at the perceptual level of processing (i.e., encoding level of faces; Fischer, Sandblom, Nyberg, Herlitz, & Bäckman, 2007) there are no gender differences, which emerge at higher processing levels (i.e., recognition and memory of faces; Rehnman & Herlitz, 2007). There was also evidence suggesting that little information is needed to process emotional facial expressions, as previously suggested (Zajonc, 1980). Furthermore, a clearer picture emerged upon examination of the β values such that there was a tendency for happy-female and neutral-female faces to be reported as emotional; this effect was demonstrated by the lower β values for happy-female faces than for the other face types. The more liberal response style may reflect a general expectation for women to express happiness.

The Non-Neutrality of ‘Neutral’

The results from Study I favor the notion of a general happy-superiority effect in detection of facial emotion. Specifically, emotion was more easily detected in happy than in angry faces and in angry-male than in angry-female faces. Furthermore, there was a greater difference in sensitivity between happy-female and angry-female faces than between happy-male and angry-male faces.

Study I was designed with emotion blocks in each of which the specific emotional face was compared to its neutral counterpart. It is worth noting that previous evidence suggests that the emotional context might have an influence on the perception of the neutral faces. Hence, the perception of the emotional expressions may have been affected by the neutral expressions or the reverse (Ekman, 1982; Esteves & Öhman, 1993; Hansen & Hansen, 1988). For example, in their study, Esteves and Öhman (1993) found that 60% of the neutral faces used were mistaken for angry faces. Thus, ‘neutral’ facial expressions may not be neutral (e.g., Donegan, Sanislow, Blumberg et al., 2003; Philips, Young, Senior et al., 1997; Thomas, Drevets, Whalen et al., 2001). Therefore, the question of whether there is a true happy superiority effect comes into play.

Thus, the manner in which the facial expression stimuli were presented in Study I is of concern, as the emotion blocks were comprised of one specific emotional expression (angry or happy) and the neutral comparison expression. A neutral facial expression may often be perceived as more negative in relation to the stimuli with which the neutral expression is being presented (e.g., Lee, Kang, Park, Kim, & An, 2008; Russell & Fehr, 1987), suggesting that the perception of facial expressions may be context dependent, as suggested by Mobbs, Weiskopf, Lau, Featherston, Dolan, and Frith (2006) and by Carroll and Russell (1996).

Russell and Fehr (1987) found that when a supposedly neutral facial expression is presented in a group of happy facial expressions the neutral facial expression tends to be perceived as sad, thus creating a built-in greater perceptual difference between happy and neutral facial expressions than between angry and neutral. Therefore, as Russell and Fehr (1987) discussed, the perception of emotional expressions can be a matter of relativism rather than a matter of absolutism; the same facial expression presented in two different contexts may be perceived as different expressions, which thus questions the methodology in Study I.

Also, although the stimulus set used in Study I was from a standardized set (Tottenham et al., 2009)[6] of emotional facial expressions, the stimulus quality of emotion was not examined in Study I. A thorough investigation of the stimuli has shown that the quality of the stimuli plays a role in the final results (cf. Calder, Burton, Miller, Young, & Akamatsu, 2001; Hampton et al., 1989; Purcell, Stewart, & Skov, 1996). Thus, given the above methodological concerns in Study I, Study II was designed to address these potential problems and to provide additional empirical data to elucidate whether the perceptual difference between angry and neutral is similar to that of happy and neutral expressions under normal viewing conditions (i.e., not using the presentation times used in Study I) or differ as has been proposed in some previous work (e.g., Smith, Cottrell, Gosselin, & Schynes, 2005).

Mean Scale Values (*MSV*s)

It is important to note that the results from Study I may simply reflect that the visual qualities differed in the particular stimuli (cf., Calder et al., 2001). The face stimuli used in Study I came from the standardized NimStim set of facial expressions (Tottenham et al., 2009) and have been used in a variety of studies in the scientific community (e.g., Hills & Lewis, 2009; Krumhuber & Manstead, 2011; Mobbs et al. (2006); Young & Hugenberg, 2010). For example, Young and Hugenberg (2010) used the NimStim set in order to investigate the effects of in-group and out-group recognition of emotions from the same culture group as the participant (in-group) or from a different cultural group (out-group).

In the development of the NimStim stimulus set, the faces were not rated "on a continuum for each type of emotion label" (Tottenham et al., 2009, p. 248). However, it has been mentioned (Russell, 1994; Russell & Bullock, 1986; Tottenham et al., 2009) that rating the faces on the particular emotion continuum could, potentially, be a better measure of emotion than classifying the stimuli into discrete emotion categories. Rating emotion, as compared to classifying the emotion into but one category, can potentially capture the subtleties, that is, the degree of emotions, that simple categorization cannot.

The happy-superiority effect found in Study I may have resulted from unequal emotional distances to neutral faces for happy and angry faces, respectively. That is, happy faces may have been better discriminated from neutral faces than were angry faces because the difference between happy and neutral faces was greater than that between angry and neutral faces. Further-

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[6] Due to copyright specifications, an example of the facial stimuli subset used in the present dissertation cannot be given. However, the full facial stimuli set can be found at http://www.macbrain.org/resources.htm.

more, this line of reasoning suggests that there may have been a greater difference in the emotional space between angry-male faces and neutral faces than between angry-female faces and neutral faces. This could have been taken into consideration by asking participants to rate all expressions on an emotional intensity scale. However, because such subjective rating values of anger, happiness, and emotionality of the three face types were not collected before conducting Study I, these possibilities could not be addressed explicitly in Study I, and the question was left unsolved.

Consequently, in line with the above reasoning, Study II addressed whether ‘angry’, ‘happy’, and ‘neutral’ facial expressions were rated as such. Therefore, all facial stimuli were rated on three different scales of Anger (Scale A, Figure 4), Happiness (Scale H, Figure 5), and Emotionality (Scale E, Figure 6). Mean scale values (*MSV*s) were obtained for the respective scale and for each face type used in Study I.

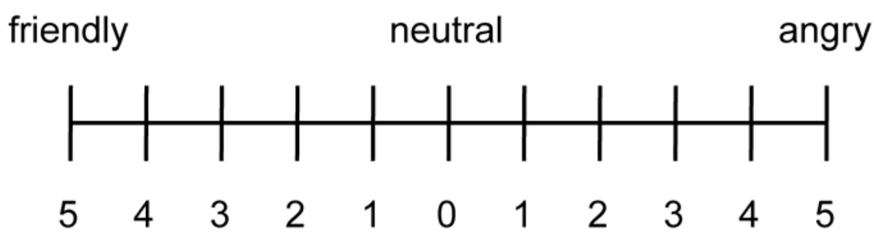

Figure 4. The 11-point emotion-intensity rating scale, friendly to angry, for male and female faces.

As has been mentioned by Russell (1994), this type of rating continuum is a more unbiased measure of emotion than the commonly used forced-choice method of categorizing pictures of facial expressions into emotion-label categories. The rating continuum allows the participant to rate the emotional expression on a degree of expressivity, instead of simply categorizing the expressions as one emotion. For example, the stimuli used may differ in expressivity such that not all angry expressions are so clearly angry, and the viewer may, therefore, interpret one particular expression less angry than another. Therefore, the rating scales used in the present work offer the participant the full ranges of the specific emotional continua (Russell & Carroll, 1999). Furthermore, the specific scales of Anger and Happiness were created in relation to the emotional space of high/low arousal and high/low pleasure (Russell & Fehr, 1987). For Anger (Figure 4), friendly is high pleasure, low arousal and anger is low pleasure and high arousal. For Happiness (Figure 5), sad is low pleasure, low arousal, and happy is high pleasure, high arousal.

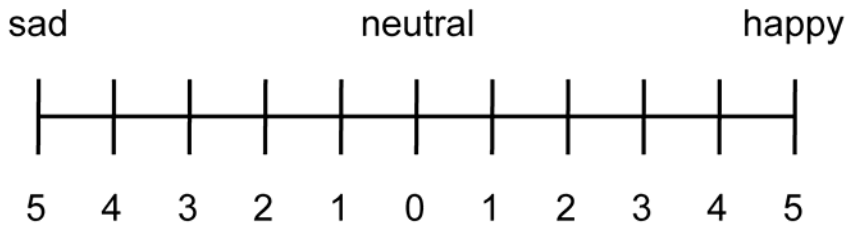

Figure 5. The 11-point emotion-intensity rating scale, sad to happy, for male and female faces.

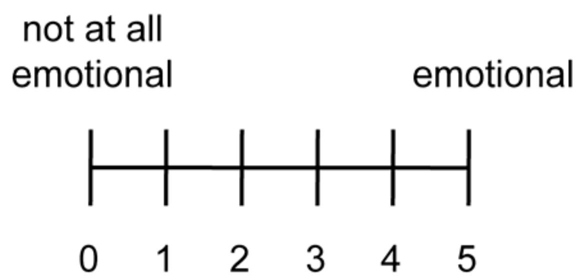

Figure 6. The 6-point emotional-intensity rating scale, not at all emotional to emotional, for male and female faces.

Mean Difference Values (*MD*s)

As suggested by, for example, Smith et al., (2005), the difference between happy and neutral facial expressions may be greater than the difference between angry and neutral facial expressions. Because *d*' depends on the perceptual difference between *target* and *nontarget* stimuli, the results in Study I may have been distorted by unwanted inequalities of this difference. Therefore, the difference between the *MSV*s for each emotion specific face type and the *MSV*s of its neutral counterpart were calculated for each of the three scale types, resulting in mean difference (*MD*) values.

Adjusted Sensitivity ($d'_{3DAdjusted}$)

It has been suggested that emotional expressions are not perceived as discrete, but rather as having varying degrees of emotionality (Russell, 1994; Russell & Bullock, 1986). Also, as mentioned by Lee et al. (2008), neutral facial expressions may be perceived as more negative than neutral. Taken together, the *d*' values in Study I may have been a reflection of the perceptual difference between the emotion specific face type and its neutral counterpart. If this is the case, then the results (e.g., the happy-superiority effect) in Study I may have been a function of such a difference.

To investigate whether there may be such a difference, the *MD*s were used to adjust the *d*' values in Study I. The assumptions were that, other things being equal, *d*' for each emotion-face type is proportional to the perceived dissimilarity of the emotional and the neutral stimulus, and that this dissimilarity can be estimated (cf. Dunn, 1983) by their Euclidean distance (*ED*) in the space defined by the three scales of Anger (Scale A), Happiness (Scale H), and Emotionality (Scale E). Thus, the adjustments were made by calculating the *ED*s for each face type: $ED = (MD_{\text{Scale A}}^2 + MD_{\text{Scale H}}^2 + MD_{\text{Scale E}}^2)^{1/2}$. The $d'_{\text{3DAdjusted}}$ values were calculated as (d'_{AF} / ED_{AF}), (d'_{AM} / ED_{AM}), (d'_{HF} / ED_{HF}), and (d'_{HM} / ED_{HM}) for each of the five presentation times (6.25, 12.50, 18.75, 25.00, 31.25 ms). Using all three emotion type dimensions in these adjustments was justified by the facts (1) that participants were presented with both angry and happy faces, (2) that neutral faces were seen in both the angry and happy conditions, and (3) that the task was to detect emotion in general and not the specific emotion.

Overview of Study II

Pixton, T. S., Hellström, Å., Englund, M. P., & Larsson, M. (2011). The non-neutrality of 'neutral' faces: Effect on discriminability of emotional expressions. *Manuscript in preparation*.

Aims

The main aim of Study II was to examine whether 'angry', 'happy', and 'neutral' faces are perceived as such and, more specifically, whether 'neutral' faces are perceived as neutral when judged on three different scales of Anger (Scale A), Happiness (Scale H), and Emotionality (Scale E). A secondary aim of Study II was to examine how the pattern of sensitivity values (as measured by d') reported in Study I would be modified when adjusting these values using the ratings of the emotional facial expressions collected in the present study.

Background

The design in Study I was such that either an emotional face (angry or happy) or a neutral face was presented, and participants were to answer *yes* if the presented face was emotional and *no* if the face was not emotional. A *yes*-response to an emotional face (the *target*) was counted as a hit, and a *yes*-response to a neutral face (the *nontarget*) was counted as a false alarm. Hence, the happy-superiority effect found in Study I might reflect a perceptual difference between a happy and neutral face that is greater than that between an angry and a neutral face.

Method

There were 103 undergraduate students (53 men, 50 women; no difference in age) who individually viewed 90 closed-mouth faces of 15 men and 15 women, each expressing anger, happiness, and a neutral mood (Tottenham et al., 2009). The faces were presented individually and participants were to rate each face on three scales: Anger (Scale A), Happiness (Scale H), and

Emotionality (Scale E). For Scale A and Scale H, there were 11-point scales (5 = *friendly*, 0 = *neutral*, 5 = *angry*; 5 = *sad*, 0 = *neutral*, 5 = *happy*, respectively), and for Scale E, there was a 6-point scale (0 = *not at all emotional*, 5 = *very emotional*). All faces were presented pseudorandomly (and controlled by Matlab software with the Psychophysics Toolbox; Brainard, 1997; Pelli, 1997) within each scale, and scale order was randomized for each participant. The session lasted for approximately 30 minutes with a total of 270 trials (90 faces per scale).

Each participant completed the task individually and was instructed to rate to which degree each face displayed a particular emotion expression (Scale A, Scale H) and its degree of emotionality (Scale E). Responses were made by using a computer mouse and clicking on the number presented on the computer monitor that corresponded to the degree of expressed emotion displayed by the face on each of the three scales. There was no time limit for each trial, and the next trial began only after the participant had entered a response.

The means of each emotion-gender face combination were calculated for each of the three scales (mean scale values, *MSV*s), and then the differences between the gender-emotion face combinations and their neutral counterparts were calculated as the mean difference scale values (*MD*s). The *MSV*s can be seen in Table 3 and the *MD*s are presented in Table 4. Thereafter, the *d*' values found in Study I were adjusted accordingly. The adjustments were made by first calculating the Euclidean distance (*ED*) of each emotional face from its neutral face in the three-dimensional (3D) space of anger, happiness, and emotionality, $ED = (MD_{\text{Scale A}}^2 + MD_{\text{Scale H}}^2 + MD_{\text{Scale E}}^2)^{1/2}$. Thereafter, the original *d*' values were adjusted as (d'_{AF} / ED_{AF}), (d'_{AM} / ED_{AM}), (d'_{HF} / ED_{HF}), and (d'_{HM} / ED_{HM}).[7]

Results

All analyses were performed with gender-of-participant and scale order as between-participant factors. Results showed no effects of these variables; therefore, all analyses were performed again without these factors.

Firstly, there was a significant difference between the *MSV*s for neutral faces in Scale H and Scale A. Neutral faces were rated towards sad on Scale H and towards angry on Scale A (see Table 3).

[7] A principal component analysis (PCA) was also conducted for the *MD* values for each face type on each of the three scale types. Then component score coefficient for each *MD* on the first unrotated component was then multiplied by the respective average *MD* value. The resulting value was then used in lieu of the *ED* to adjust the original *d*' values. Analyses on the PCA-adjusted *d*' values led to similar conclusions as for the *ED*-adjusted values.

Table 3. *Mean (M) and Standard Deviation (SD) of Ratings of Emotion Specific Expression and Emotionality in the Six Emotion-Gender Face Types*

	Scale Type					
	Scale A: Anger		Scale H: Happiness		Scale E: Emotionality	
Face Type	*M*	*SD*	*M*	*SD*	*M*	*SD*
Angry						
Male	2.72	0.97	-2.23	1.07	3.34	0.79
Female	2.86	0.96	-2.37	1.13	3.50	0.82
Total	2.79	0.94	-2.30	1.08	3.42	0.79
Happy						
Male	-2.95	0.85	2.82	0.72	3.31	0.59
Female	-3.15	0.86	2.95	0.70	3.30	0.62
Total	-3.05	0.83	2.88	0.66	3.30	0.59
Neutral						
Male	0.11	0.41	-0.48	0.55	0.83	0.73
Female	0.26	0.45	-0.81	0.69	1.06	0.81
Total	0.18	0.41	-0.65	0.60	0.95	0.75

Secondly, results showed that there were greater *MD*s between happy and neutral faces on Scale H than between angry and neutral faces on Scale A (see Table 4). This difference in *MD*s was not driven by a difference between *MSV*s for happy faces on Scale H and angry faces on Scale A, but by a difference between *MSV*s for neutral faces on Scale H and on Scale A. Interestingly, the *MD*s on Scale E were not significantly different between angry-male and angry-female faces, but were significantly different between happy-male and happy-female faces. Further, the latter difference was not driven by a difference in the *MSV*s between happy-male and happy-female faces, but between the *MSV*s of neutral-male and neutral-female faces, where the neutral-female faces were rated as more emotional than the neutral-male faces.

Table 4. *Mean Difference (MD) Scale Values of Rated Emotional Expression in the Three Scale Types and Three-Dimensional (3D) Euclidean Distance (ED) Values for the Six Emotion-Gender Face Types*

Face Type	Scale Type			*3D Euclidean Distance*
	Scale A: Anger	Scale H: Happiness	Scale E: Emotionality	
Female				
Angry/Neutral	2.61	-1.56	2.43	*3.89*
Happy/Neutral	-3.40	3.76	2.24	*5.55*
Male				
Angry/Neutral	2.60	-1.74	2.51	*4.02*
Happy/Neutral	-3.10	3.30	2.48	*5.14*

Lastly, the results for the $d'_{\text{3DAdjusted}}$ values showed that the values were modified (see Figure 2 for the original d' values). As presentation time increased, the $d'_{\text{3DAdjusted}}$ values for happy faces and angry-male faces merged. However, the adjusted d' values of angry-female faces remained lower than the other emotion-gender face types. This shift in the $d'_{\text{3DAdjusted}}$ values can be seen in Figure 7.

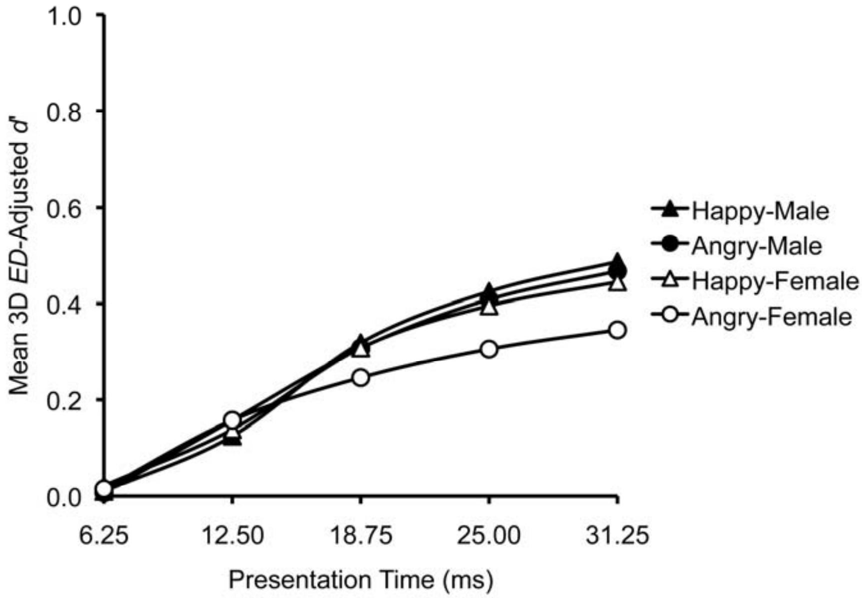

Figure 7. Three-dimensional (3D) Euclidean distance adjusted sensitivity ($d'_{3DAdjusted}$) for each emotion-gender face combination at five presentation times.

Conclusions

The ‘neutral’ faces were not as neutral when rated for anger-friendliness and happiness-sadness, whereas our angry and happy faces were rated equally angry or happy on the respective scale. This made the perceived difference greater between happy and neutral faces than between angry and neutral faces. The *d*' values found in Study I, where emotion-gender faces were to be distinguished from their neutral counterparts, seemed to be, therefore, affected by this ‘built-in’ difference. When adjusting the *d*' values for the ratings of each emotion-gender face type, the general happy-superiority effect disappeared, as discrimination from neutral faces did not differ between the happy-male and angry-male faces. Replicating the findings from Study I, discrimination of angry-female faces was the most difficult.

The results from Study II showed that after adjusting the *d*' values from Study I, when taking into consideration rated facial anger, happiness, and emotionality, a partial happy-superiority effect remained. There was no longer a difference between happy-male and angry-male faces; indicating that it became easier to discriminate angry males. The $d'_{3DAdjusted}$ values remained lower for the angry-female face stimuli than for the other stimuli.

The observations from Study II also suggest that the happy-superiority effect may be driven by the particular stimuli. The non-neutrality of assumedly 'neutral' facial stimuli and, specifically, the difference between male and female 'neutral' faces (in that neutral-female faces were rated as more emotional than neutral-male faces on Scale E, Study II) seem to add to the list of potential methodological problems in previous literature using neutral faces as the comparison stimuli, which was mentioned by Lee et al. (2008). Lee et al. found that neutral faces were evaluated in a similar manner as fearful faces, which were rated negatively. Consequently, the results from Study II demonstrate how the selection of stimuli affects the evaluation of emotional facial expressions.

Again, as mentioned previously, the face stimuli used in Study I came from the standardized NimStim set of facial expressions (Tottenham et al., 2009) and have been used in a variety of studies (e.g., Hills & Lewis, 2009; Krumhuber & Manstead, 2011; Young & Hugenberg, 2010). However, as Tottenham et al (2009) discuss, the neutrality of 'neutral' faces should be thoroughly addressed. Furthermore, the face stimuli in the NimStim set were categorized and not rated for degree of emotion expressiveness. As Tottenham et al. mentioned, this would be quite the undertaking given the number of stimuli in the set. In light of this, only the stimuli used in the present dissertation have been examined by rating them on an emotion continuum.

Also, the results revealed that 'neutral' facial expressions were not perceived as neutral, and the *d*' values observed in Study I were significantly affected by a greater perceptual difference between happy and 'neutral' than between angry and 'neutral', as demonstrated by the $d'_{3DAdjusted}$ values found in Study II. Another potential concern with these results is that the original *d*' values and the *MD* values used to calculate the $d'_{3DAdjusted}$ values derived from two different samples of participants. Therefore, the rating values found in the present study may not be appropriate for adjustment of the *d*' values found in Study I to compensate for the potentially greater perceptual difference between happy and neutral than between angry and neutral facial stimuli.

General Emotion Detection

In Study I, the happy and angry expressions were presented in separate sessions. This procedure may have caused the participants to use different strategies in each session. For the happy-versus-neutral sessions, the participant may judge the faces as simply ‘happy, not happy’, and for the angry-versus-neutral sessions, the participant may judge the faces as ‘angry, not angry’.

In addition, different expressions (happy, angry) are associated with different features (Smith et al., 2005) that are used in determining whether the face displays one emotional expression or another. Therefore, presenting angry and happy versus neutral facial expressions in different sessions may lead the participant to attend to different parts of the face for each emotion-type session. To account for this potential specificity of visual attention, Study III, Experiment 1, was designed to use both happy and angry versus neutral facial expressions in one session. Given that the briefest and longest presentation times used in Study I were removed for Study III, all faces could be combined into one experimental session without losing data points.

Emotion-Specific Detection

Another question addressed in Study III regarded the number of times the neutral faces were presented in comparison to the angry and happy faces. The neutral faces were presented twice as often as the angry and happy faces, which may have produced a familiarity effect for the neutral faces. Therefore, as the experiment in Study I or Study III, Experiment 1, progressed, participants became possibly overexposed to the neutral faces in comparison to the angry and happy faces, thus becoming more familiar with the neutral faces than either the angry or happy faces. Potentially, the participants may, therefore, have recognized the neutral face more easily (see Footnote 5). Therefore, in Study III, Experiment 2, participants were divided into two groups. One group detected angry faces among neutral faces, and the other group detected happy faces among neutral faces. Importantly, in both groups the emotional and neutral faces were presented an equal number of times.

Furthermore, Experiment 2 in Study III was designed to address the question whether discrimination improves when the participant is asked to detect the specific emotion, rather than detecting emotion in general, as was the case in Study I and Study III, Experiment 1. As has been suggested (e.g., Lindquist, Feldman-Barrett, Bliss-Moreau, & Russell, 2006; Manis, 1967; Pons, Lawson, Harris, & de Rosnay, 2003; Widen & Russell; 2003), language influences perception of emotions and, specifically, their categorization. If this is the case, then the *d*' values found in Study I may, in theory, reflect an influence of language. By giving specific instructions to detect anger or to detect happiness, the specific emotion (angry or happy) may be easier to detect than emotion, in general, especially when there is only one emotion to be detected. Indeed, Green (1961) found that auditory signals in noise were more easily detected (i.e., yielded higher *d*' values) when there was one *target* signal of a single frequency rather than several of varying frequencies. This, in turn, could result in anger and happiness being detected equally well, thus decreasing or removing any type of superiority effect.

Additionally, a further purpose of designing Study III, Experiment 2, as a between-groups experiment was to validate the within-participant designs of Study I and Study III, Experiment 1. As noted by Russell (1994), a within-participant design results in the participants directly comparing the stimuli that are presented, compared to a between-groups design in which the participants are only presented with a part of the stimulus subset. Thus, both types of designs are needed to verify results. Therefore, one of the aims of Study III, Experiment 2, was to investigate whether the results from Study I and Study III, Experiment 1, could be replicated.

Overview of Study III

Pixton, T. S., Englund, M. P., & Hellström, Å. (2011). Are you emotional or simply happy? Detection and perceived intensity of anger, happiness, and emotionality in male and female faces. *Manuscript in preparation*.

Aims

There were two main aims of Study III. The first aim (Experiment 1) was to examine whether the observations from Studies I and II could be replicated with each participant performing both a signal detection task, detecting emotion (Study I), and a rating task (Study II) within the same study. The second aim (Experiment 2) was to examine whether either the happy- or anger-superiority effects remain when participants are asked to detect the specific emotion (angry or happy), rather than general emotion as was measured in Study I. Study III, Experiment 2, was designed as a between-groups study with one group detecting angry versus neutral faces and one group detecting happy versus neutral faces, as well as completing a rating task for perceived emotion.

Background

The results from Study II showed that there was a greater distance on the relevant judgment scales between happy and neutral expressions than between angry and neutral expressions. The *MD*s were calculated for each emotion-gender face combination and subsequently used to adjust the *d*' values found in Study I. The results from Study I showed higher *d*' values for happy faces, and the results found in Study II showed that adjusted *d*' values for all combinations were similar except for the angry-female faces for which lower values were shown.

One potential problem with the results from Study II is that the original *d*' values (Study I) and the *MD*s (Study II) used to calculate the adjusted *d*' values reported in Study II are based on different groups of participants. Therefore, the purpose of Study III was to replicate and combine those two studies so that each participant performed both a signal detection task and a rating task.

Method

In Experiment 1, there were 43 participants. For Experiment 2, there were 85 participants who were divided into two groups of anger-detection (n = 42) and happiness-detection (n = 43). Between the three groups, there were no differences in age or sight, as measured on the LogMar eye chart (Bailey & Lovie, 1976). All participants were exposed to the same stimuli as were used in Studies I and II, and there were two tasks for each experiment, a detection task (approx. 45 min) followed by a rating task (approx. 30 min). For the detection task in Experiment 1, each of the 30 neutral faces was presented four times, and each of the 30 emotional (angry and happy) faces were presented twice at three presentation times (12.50, 18.75, and 25.00 ms)[8] for a total of 720 trials.

All faces were presented in a pseudorandom order. In Experiment 1, the participant was to answer *yes* if the face was emotional and *no* if the face was not emotional; in Experiment 2, the participant was to answer *yes* if the face was angry or happy (depending on the group) and *no* if the face was not angry or happy. For the rating task in Experiment 1, each of the 90 pictures was rated individually on three emotion scales; Scale A (anger), Scale H (happiness), and Scale E (emotionality). There were 11-point rating scales for Scale A and for Scale H (5 = *friendly*, 0 = *neutral*, 5 = *angry* and 5 = *sad*, 0 = *neutral*, 5 = *happy*, respectively) and a 6-point rating scale for Scale E (0 = *not at all emotional*, 5 = *very emotional*). The participant was instructed to answer to what degree she or he thought the face exhibited an emotional expression indicated for each scale. The stimuli were presented pseudorandomly (controlled by Matlab software with the Psychophysics Toolbox (Brainard, 1997; Pelli, 1997) within each scale session, and scale order was counterbalanced across participants. There were a total of 270 trials (90 per scale).

For the detection task in Experiment 2, the 30 neutral faces and 30 emotional faces (angry or happy, group dependent) were presented four times at each of the three presentation times. The rating task was similar as in Experiment 1; however, 60 faces (30 angry or 30 happy, and 30 neutral) were presented individually for each of the three scales (friendly-angry, sad-happy, and not at all emotional-very emotional) for a total of 180 trials.

For both Experiment 1 and Experiment 2, results were calculated as was done in Studies I and II. Also, as in Study II, the d' values from the detection task for Experiments 1 and 2 were adjusted ($d'_{3DAdjusted}$) using the *MD*s from

[8] The results from Study I showed that at the briefest presentation time (6.25 ms), happy-female faces only differed significantly from chance-level (the other d' values nearing floor effect values), and at the longest presentation time (31.25 ms), the d' values neared ceiling effect values (as discussed by Macmillan & Creelman, 2005; Weins et al., 2008). Therefore, the briefest and longest presentation time that were used in Study I were not included in Study III.

the rating task to calculate the Euclidean distances in the 3D space of anger, happiness, and emotionality, $ED = (MD_{\text{Scale A}}^2 + MD_{\text{Scale H}}^2 + MD_{\text{Scale E}}^2)^{1/2}$. The resulting $d'_{\text{3DAdjusted}}$ were, thus, calculated as $(d'_{\text{AF}} / ED_{\text{AF}})$, $(d'_{\text{AM}} / ED_{\text{AM}})$, $(d'_{\text{HF}} / ED_{\text{HF}})$, and $(d'_{\text{HM}} / ED_{\text{HM}})$.

For Study III, the $d'_{\text{3DAdjusted}}$ values were calculated individually according to each participant's *ED*s. This was not possible in Study II, because the original *d*' values and the *MD*s were from two different participant sample groups, Study I and Study II, respectively.

Results

As in Study I, the mean values for each face type were calculated for *d*' and β for both Experiment 1s and 2. For Experiment 1, these values were submitted to a 2 x 2 x 3 (Emotion [angry, happy] x Gender-of-Face [male, female] x Presentation Time [12.50, 18.75, 25.00]) repeated-measures ANOVA. For Experiment 2, these values were submitted to a 2 x 3 (Gender-of-Face [male, female] x Presentation Time [12.50, 18.75, 25.00]) mixed-effects ANOVA with Group (Angry, Happy) as a between-participant factor. Next, as was performed in Study II, the *MD*s were calculated from the *MSV*s for each face type on the three scales and analyzed, and the *d*' values were adjusted accordingly. Also, the new $d'_{\text{3DAdjusted}}$ values were submitted to ANOVAs as was done for *d*' and β for both experiments.

Experiment 1: General Emotion Detection

Sensitivity (*d*')

As shown in Figure 8, the results indicated that happy faces were detected better than angry faces, male faces were detected better than female faces, and as presentation time increased the overall *d*' values also increased. The *d*' values for angry-female faces increased at a lesser rate than for the other emotion-gender face types. As in Study I (*d*') and Study II ($d'_{3DAdjusted}$), the *d*' values for angry-female faces were lower than for happy-female, happy-male, and angry-male faces, but the angry-male advantage over angry-female was less pronounced than in Study I.

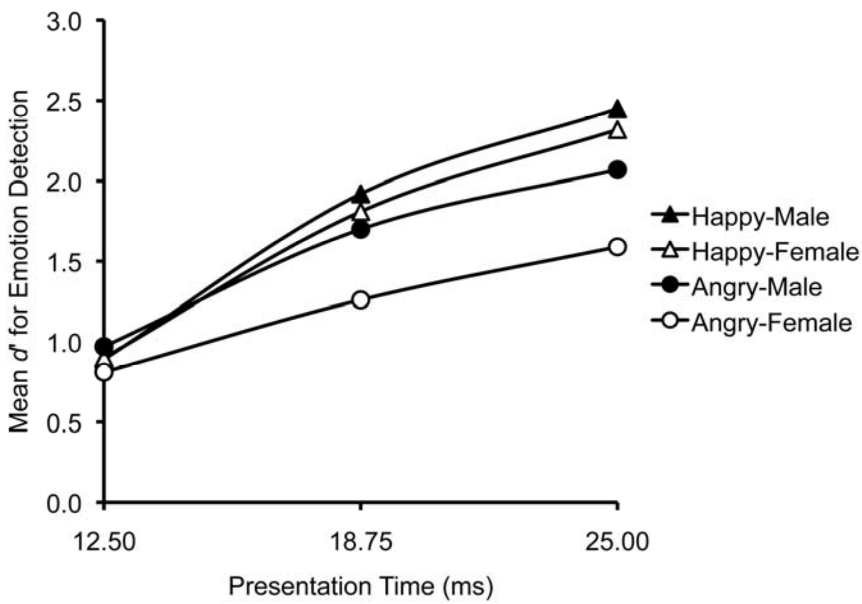

Figure 8. Experiment 1: Mean sensitivity (*d*') for each emotion-gender face combination at three presentation times for emotion detection.

Response Bias (β)

There were significantly higher β values for angry than for happy faces (see Figure 9), and no difference between male and female faces. As presentation time increased, the β values for happy faces decreased, whereas those for angry faces, regardless of facial gender, remained relatively constant. Thus, participants were more apt to report happy faces as emotional. Happy-female faces differed from the other face types only at 18.75 ms. This result differs from Study I where happy-female faces had lower β values, and thus were reported more often as emotional than other faces, at both 18.75 and 25.00 ms.

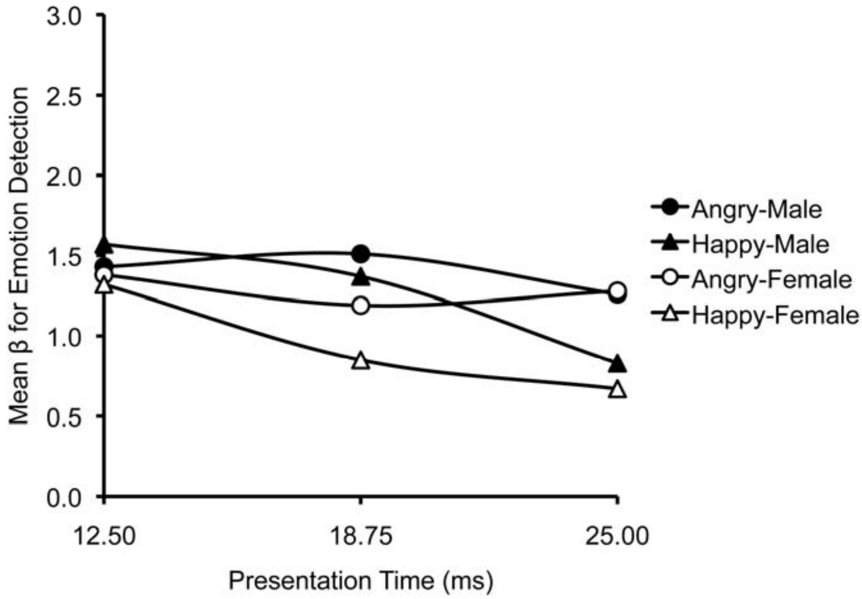

Figure 9. Experiment 1: Mean response bias (β) for each emotion-gender face combination at three presentation times for emotion detection.

Mean Difference (*MD*s)

As reported in Study II, the results showed that the *MD*s (see Table 5 for overall values) differed from one another on each scale type. With further analyses for the mean scale values (*MSV*s), happy faces were rated equally happy as angry faces were rated angry; however, the neutral faces were rated somewhat sad and somewhat angry on the respective scales. Therefore, there was a greater perceptual difference between happy and neutral faces than between angry and neutral faces. However, for emotionality, angry faces were rated higher than happy faces; therefore, there was a greater distance between angry and neutral faces than between happy and neutral faces.

Table 5. *Experiment 1: Means (and Standard Deviations) of the Mean Differences (MD) and Euclidean Distances (ED) in the Emotional Space for the Specific Face Type and its Neutral Counterpart for Emotion Detection in One Group*

Emotion	Gender of Face	Scale Type			*3D Euclidean Distance*
		Scale A: Anger	Scale H: Happiness	Scale E: Emotionality	
Angry/ Neutral	Male	3.30 (0.86)	-2.18 (1.19)	2.75 (0.75)	*4.97 (1.05)*
	Female	3.24 (0.80)	-2.11 (1.15)	2.73 (0.73)	*4.89 (0.96)*
Happy/ Neutral	Male	-3.65 (1.01)	3.57 (0.89)	1.91 (0.95)	*5.57 (1.20)*
	Female	-4.02 (1.20)	4.10 (1.04)	1.63 (1.03)	*6.09 (1.41)*

3D Adjusted Sensitivity (*d'*$_{3DAdjusted}$)

After adjusting the *d'* values with the 3D Euclidean distances for each specific face type, the results showed that the overall *d'*$_{3DAdjusted}$ values increased with presentation time (see Figure 10) and that this increase was greater for happy than for angry faces and greater for male than for female faces. Interestingly, further analyses showed there were no differences between the face types at 12.50 ms; however, the *d'*$_{3DAdjusted}$ values for angry-female faces remained lower than for the other face types at both 18.75 and 25.00 ms. Again, as was found in Study II, *d'*$_{3DAdjusted}$ values merged closer together with increasing presentation time with the exception for angry-female faces.

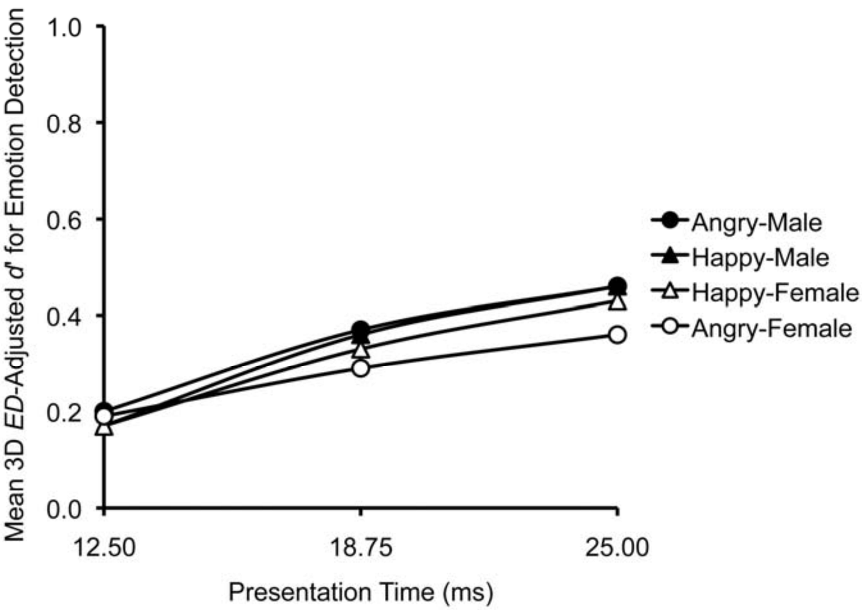

Figure 10. Experiment 1: Three-dimensional (3D) Euclidean distance adjusted sensitivity (*d'*$_{3DAdjusted}$) for each emotion-gender face combination at three presentation times for emotion detection.

Experiment 2: Emotion-Specific Detection

Sensitivity (*d*')

As shown in Figure 11, the *d*' values were greater in the happy-detection group than in the angry-detection group, and the *d*' values for both groups increased with increasing presentation time. Female faces were detected better than male faces in the happy-detection group, reflecting a happy-female superiority effect. However, these *d*' values approached four (i.e., potential ceiling effects). In the angry-detection group, male faces were detected better than female faces.

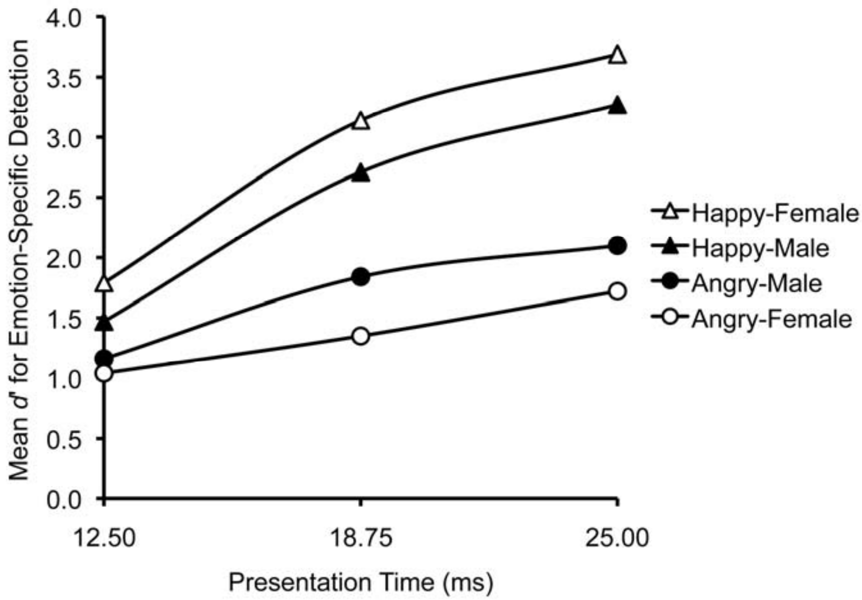

Figure 11. Experiment 2: Mean sensitivity (*d*') for each emotion-gender face combination at three presentation times for emotion-specific detection for two groups (angry, happy).

Response Bias (β)

There was an overall difference between the two emotion-specific detection groups in answering style (see Figure 12) in that the β values decreased at a greater rate for happy faces than for angry faces, as seen in Study I and in Study III, Experiment 1. Participants were more conservative in answering that a presented face was angry than for happy. The β values were in the range of two to three, indicating a tendency to answer *no*, the face was not angry or happy, with the exception for happy-female faces. Replicating the findings from Study I and Study III, Experiment 1, participants answered most readily that happy-female faces were happy.

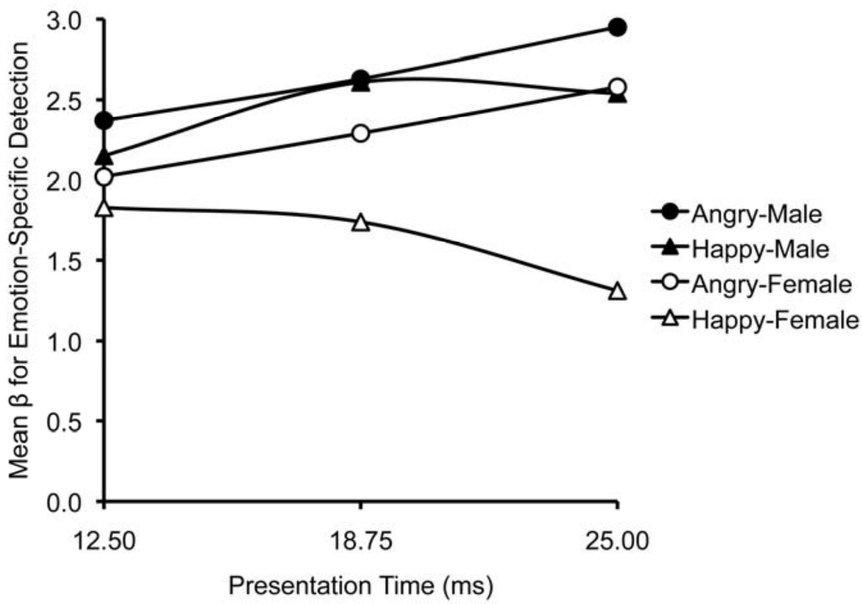

Figure 12. Experiment 2: Mean response bias (β) for each emotion-gender face combination at three presentation times for emotion-specific detection for two groups (angry, happy).

Mean Difference (*MD*s)

Results showed that for the happy-detection group the *MD*s for female faces were greater than for male faces (see Table 6 for overall values), but no such difference was found for the angry-detection group. Also, the *MD*s for happy-female faces were greater than those for angry-female faces with no such difference between the *MD*s for happy- and angry-male faces. For the angry-detection group, there was no difference between the *MSV*s of neutral faces when rated on Scale A and on Scale H; however, for the happy-detection group, this difference was significant.

Table 6. *Experiment 2: Means (and Standard Deviations) of the Mean Difference (MD) Values and Euclidean Distances (ED) in the Emotional Space for the Specific Face Type and Its Neutral Counterpart for Emotion-Specific Detection for Two Groups (Angry, Happy)*

Emotion	Gender of Face	Scale Type: Scale A: Anger	Scale Type: Scale H: Happiness	Scale Type: Scale E: Emotionality	*3D Euclidean Distance*
Angry/ Neutral	Male	2.84 (0.90)	-2.40 (1.13)	3.12 (0.85)	*4.94 (1.39)*
	Female	2.82 (0.84)	-2.21 (1.04)	2.91 (0.81)	*4.71 (1.23)*
Happy/ Neutral	Male	-3.36 (0.89)	3.27 (0.72)	2.83 (0.73)	*5.52 (1.15)*
	Female	-3.61 (1.09)	3.61 (0.85)	2.46 (0.70)	*5.75 (1.24)*

3D Adjusted Sensitivity (*d*'$_{3DAdjusted}$)

After adjusting the *d*' values with the *ED* values, the results differed from the unadjusted *d*'. As shown in Figure 13, the *d*'$_{3DAdjusted}$ values were greater for happy than for angry faces and increased with increasing presentation time. The happy-female advantage that was found for the original *d*' values disappeared in that the *d*'$_{3DAdjusted}$ values for both male and female happy faces did not differ at 18.75 and 25.00 ms. For angry faces, there remained a male advantage in comparison to female faces, which was not found for the *d*'$_{3DAdjusted}$ values in Study II or Study III, Experiment 1.

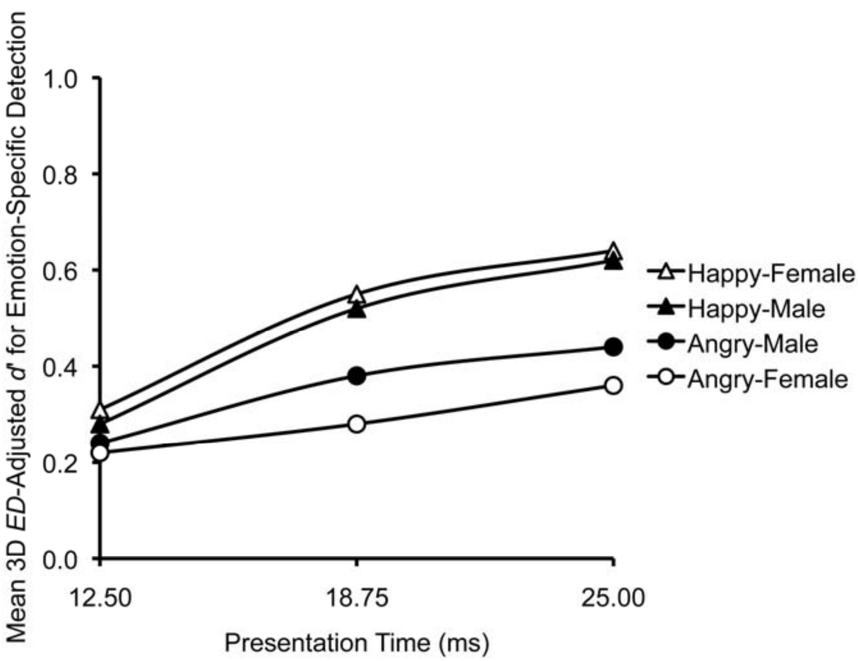

Figure 13. Experiment 2: Three-dimensional (3D) Euclidean distance adjusted sensitivity (*d*'$_{3DAdjusted}$) for each emotion-gender face combination at three presentation times for emotion-specific detection for two groups (angry, happy).

Conclusions

As shown in Study I, the *d*' values of Study III suggest a happy-superiority effect, regardless when detecting emotion or detecting the specific emotion of anger or happiness. However, this effect was not as pronounced after the adjustment of the *d*' values for Experiment 1. Here, as in Study II, the presumedly neutral facial stimuli were not perceived as neutral when rated on Scale A and Scale H, whereas the happy faces were rated equally happy, as the angry faces were rated angry. However, on Scale E angry faces were rated more emotional than happy faces creating a greater distance between angry and neutral faces than between happy and neutral faces for that specific rating scale. With this said, the *ED* values were higher for happy than for angry faces.

In summary, when combining the results from Study III with those of Studies I and II, it is evident that the overall results shift as a function of the type of stimuli used. A stable finding across Studies I, II, and III is that the angry-female faces remained more difficult to detect than the other gender-emotion face combinations. This result supports the notion that angry women tend not be perceived as threatening, as has been previously discussed in the literature (e.g., Becker et al., 2007).

Where It All Comes Together

To recapitulate, the overall aim of this doctoral dissertation was to examine the anger- and happy-superiority effects reported in emotion detection tasks, that is, tasks with singly presented stimuli. As a first step, the detection of emotional expressions (i.e., anger and happiness) was examined, whether sensitivity (*d*') and response bias (β) depend on the gender of the stimulus face and the gender of the participant. Secondly, the effect of perceived intensity of the stimuli used was taken into consideration. Thirdly, the aim was to examine whether the obtained results could be replicated in a within-participants design (Study III, Experiment 1) by combining the designs of Studies I and II.

With the hope of not being too repetitive, this section will begin with a concluding summary of the overall findings from the three studies, including a repetition of the four aims given under Research Aims. The overall implications of this dissertation will then be discussed, followed by points of caution with regard to the present work and research on emotional facial expression in general. Thereafter, suggestions for future research will be presented, followed by some final words on the matter.

Concluding Summary

Again, the main aims of the present dissertation were as follows:

1. *Study I:* To examine the detectability (i.e., sensitivity, *d*') and response bias (β) of emotion in angry and happy male and female faces using a signal detection paradigm. A secondary aim was to examine whether sensitivity and response bias are influenced by gender-of-participant, gender-of-face, and presentation time.
2. *Study II*: To examine whether 'neutral' faces are perceived as neutral when judged on three different scales of Anger (Scale A), Happiness (Scale H), and Emotionality (Scale E). A secondary aim was to examine whether the sensitivity values reported in Study I would be modified when adjusting for a potential greater difference in rated intensity between happy and neutral than between angry and neutral facial expressions by calculating the

perceived intensity of the angry, happy, and neutral facial expressions used in Study I.

3. *Study III, Experiment 1*: To examine whether the combined results found in Studies I and II could be replicated using a within-participant design where each participant completed both a signal-detection task for emotion (cf. Study I) and an emotion-rating task (cf. Study II).
4. *Study III, Experiment 2*: To examine whether the happy-superiority effect found in Studies I and III, Experiment 1, could be replicated using a between-groups design with one group detecting anger and another group detecting happiness.

The main results from this dissertation suggest that happiness tends to take precedence (Aims 1, 2, 3, & 4), regardless of the gender of the participant. However, a clearer picture of the effect emerges when taking into consideration the manner with which participants answered, as shown by the response bias measures (β values, Studies I & III) as well as the *d*' values for angry-female faces (Studies I, II, & III). Participants were biased in favor of happy-female faces (indicated by lower β values) and angry-female faces were more difficult to detect (indicated by lower *d*' values) than the other face types.

However, when the perceived emotional intensity of the stimuli was taken into consideration (Aim 2), the picture changed. Firstly, 'neutral' facial expressions were shown to be non-neutral, such that there was a greater perceptual difference between happy and neutral facial expressions than between angry and neutral facial expressions. Happy faces were rated equally happy as angry faces were rated angry. However, the ratings of neutral faces were not equal in the two scales; neutral faces were rated as somewhat sad and somewhat angry (Studies II & III). Modifying the sensitivity results of Study I using the emotion ratings of the faces (a novel aspect of the present dissertation), the general happy-superiority effect disappeared as the adjusted *d*' values for angry-male faces became similar to those of happy faces. The *d*' values for angry-female faces remained lower than for the other face types, conforming the angry-female disadvantage in facial emotion detection.

Upon further investigation, when the same group of participants performed both detection and rating tasks, divided into three separate groups of emotion-detection, angry-detection, and happy-detection (Aims 3 & 4), the results were similar with few differences. Again, a happy-superiority effect was found; a happy-female superiority effect was also found when detecting the specific emotion, an effect that disappeared when the rated emotion and emotionality of the stimuli was taken into account. Although in Experiment 2, participants only rated happy versus neutral faces (happy-detection group) or angry versus neutral faces (angry-detection group), the non-neutrality of 'neutral' faces found in Study II and Study III, Experiment 1, was replicated.

In Study II, the advantage for angry-male over happy-male faces disappeared with adjustment, (Aim 1) but this did not occur in Study III, Experiment 2. As was also found in Studies I and II, angry-female faces were more difficult for participants to detect, having lower *d*' and $d'_{3DAdjusted}$ values than the other face types in Study III, Experiments 1 and 2. Also, participants still had a bias in favor of happy-female faces (Aim 1), no matter if the task was to detect emotional faces (Experiment 1) or happy faces (Experiment 2) (Aims 3 & 4). Unexpectedly, the *d*' values in Study III, Experiment 2, were notably higher for the happy-detection group than the *d*' values were in Study I, suggesting that happy faces are considerably easier to detect when only detecting happiness instead of emotion.[9]

In summary, that which remained the same for each of the studies presented here is that angry-female faces were more difficult to detect than the other face types (Studies I, II, & III), and that participants had a response bias to tend to answer that a happy-female face was either emotional or happy (Studies I & III). Also, happy faces were rated as equally happy as angry faces were rated angry with the difference being that neutral faces were rated as somewhat angry on the anger-friendly continuum and somewhat sad on the happy-sad continuum (Study II) a finding that was replicated in Study III (Aims 3 & 4).

Implications

The overall implications of this dissertation are several-fold. The first implication is that, at least for *yes-no* tasks, happiness is more easily detected in faces than anger (Studies I & III). This is hardly surprising given the evidence from previous studies in categorization/recognition tasks (e.g., Esteves & Öhman, 1993; Grimshaw et al., 2004; Kirouac & Doré, 1983, 1984; Leppänen & Hietanen, 2004; Milders et al., 2008) and also in some visual search tasks (e.g., Calvo & Nummenmaa, 2008; Juth et al., 2005; Öhman et al., 2010). Furthermore, it seems that angry-female faces may be more difficult to detect (Studies I, II, & III) when detecting emotion or, specifically, anger. This angry-female disadvantage remained regardless of the type of modifications that were performed with each succeeding experiment, and did not disappear with the 3D *ED* adjustments. This finding has been reported previously in the literature (e.g., Becker et al., 2007) and supports the notion of an expectancy of women to look happy, displaying signs of care and friendliness. This angry-female disadvantage may also reflect a difference in the

[9] In a closer investigation, the false alarms from Study I and Study III, Experiment 2, were compared for the happy-face conditions. These analyses showed that, indeed, in Study I, there were more false alarms (*yes*-responses on neutral face trails) in Study I than in Study III, Experiment 2. This indicates further that when participants were asked which specific emotion was presented, the ability to detect the specific facial expression increased.

physical formation of female faces verses male faces, such that male faces tend to have larger and thicker brows than women with deeper set eyes (e.g., Brown & Perrett, 1993; Burton et al., 1993) than women, making it easier for the perceiver to detect anger in the male face.

The emotion-rating results and the resulting shifts in the patterns of the detection results after adjustment are important findings of the present dissertation. These results suggest that researchers need to validate their stimuli's degree of emotionality in order to conclude whether superiority effects should be attributed to characteristics of the stimulus sets or to perceptual or cognitive processes. For example, if one is using faces expressing different emotions in a study, and one face type is more salient (farther away from the other emotions) in the emotional space, its superiority may be the result of its salience.

The present results (1) ties into previous discussion in the literature on the neutrality of neutral faces and (2) expands upon the existing literature in other aspects:

(1) Regarding the discussion on neutrality of neutral faces, closer examination of the stimuli showed that, although happy and angry faces were rated equally happy and angry on their respective scales, neutral faces were not rated as such on the different emotion-type scales. This suggests that the use of neutral faces as baseline comparison stimuli may not be the ideal (e.g., Lee et al., 2008), and suggest further that neutrality is not necessarily the zero-middle point of other emotional expressions. With this said, Carrera-Levillain and Fernandez-Dols (1994) and Shah and Lewis (2003) suggested that neutral facial expressions may, in fact, represent an emotion in and of itself. If neutrality is its own emotional category, then perhaps neutrality is a malleable emotion that is not as discrete as anger or happiness (as demonstrated by the equality of the rating scores for happy and angry faces on their respective scales).

(2) Other authors have discussed related issues of stimulus sets, for example intensity and saliency of the emotional expressions, as well as methodological questions (e.g., Leppänen & Hietanen, 2004; Leppänen, Tenhunen, & Hietanen, 2003; Russell, 1984). However, it does not appear that stimulus quality (e.g., how angry faces are and how happy faces are) of the particular stimulus set has been discussed (see Hampton et al., 1989; Purcell et al., 1996 for exceptions), as well as how and in which manner the quality affects the outcome. Nevertheless, to the best of my knowledge, the work presented here seems to include the first explicit attempt to control and adjust for the emotionality of the faces, and their relations in the emotional space, in an emotion-detection task. This attempt resulted in observed shifts in the *d*' values demonstrating that although a stimulus set may be adjusted, and used extensively by the scientific community (e.g., Hills & Lewis, 2009; Krumhuber & Manstead, 2011; Tottenham et al., 2009; Young & Hugenberg, 2010), this does not necessarily mean that the emotional stimuli of the

respective gender and emotion category are equivalent to each other. Clearly, these are all topics that need further investigation and attention in the scientific community.

Also, when taking into consideration the manner in which participants answered, there appears to be a response bias towards answering that happy-female faces are emotional (Study I & Study III, Experiment 1) or happy (Study III, Experiment 2). This happy-female bias suggests that women are expected to look happy and smile, which supports the notion that femaleness is often coupled with nurturance and friendliness, as has been previously suggested (e.g., Becker et al., 2007; Hess et al., 2009), and that we are less prepared to notice cues that signal that they are angry. However, there are, of course, situations in which women are expected to not look happy, such as catwalk models who may be perceived as looking angry and never smiling. However, for these particular women, it is also expected that they are not to be seen, but, rather, they are to be human figures displaying the designers' clothes. The clothes are to be seen, not the women wearing them. This may be an example of 'art' imitating life, or rather 'art' imitating perceptual performance: The difficulty of detecting angry women, coupled together with a relatively conservative response bias for angry-female faces (as demonstrated in Studies I & II).

The robustness of the response bias in favor of happy-female faces suggests that researchers need to take precautions when designing studies. For example, these results suggest that researchers studying emotion discrimination using percent correct as a performance measure overestimates the ability to detect happiness in female faces. Therefore, researchers should strive to use performance measures that are independent of potential response bias, and to that aim, signal detection analysis is a sound method.

In addition to the mentioned gender-of-face effects, it should also be mentioned that no gender-of-participant effects were found in Studies I or II; therefore, the latter effect was not considered in Study III. As discussed in Study I, a potential explanation of these findings is that at such brief presentation times, processing is at the perceptual level at which point there may not be gender-of-participant effects, as suggested by Fischer et al. (2007). Whereas at higher-level processing, gender-of-participant effects emerge where women perform better than men at recognizing and remembering faces (e.g., Lewin & Herlitz, 2002; Rehnman & Herlitz, 2007; Wahlin et al., 1993) and at decoding emotional expressions (e.g., Hall, 1978; Hall & Matsumoto, 2004; Montagne et al., 2005).

Also, although a angry-male advantage, in comparison to angry-female, was found in Study I and in Study III, Experiment 1, this effect disappeared upon 3D *ED* adjustment of the *d*' values (Study II & Study III, Experiment 1). With the adjustments in Study III, Experiment 2, this relative angry-male advantage reappeared. Interestingly, however, in Study III, Experiment 2, the *d*' values were greater for happy-female than for happy-male faces, and this effect was lessened upon adjustment of the *d*' values.

Points of Caution

The studies in the present dissertation were planned to pinpoint a specific area of research within the vast literature on emotional face perception. The studies were designed chronologically with one study addressing potential concerns from the preceding study; however, there are points of caution to be considered, which will be addressed here. As Steinbeck (1937) famously adapted, "The best-laid plans of mice and men often go awry." Although the true meaning of this quote does not necessarily describe this dissertation, "The best-laid plans of mice and men…" do need to be scrutinized again and again, as such these plans can, indeed, "…go awry." Scrutinizing research can continue endlessly; therefore, in this section, three points of caution will be discussed.

Firstly, one of the central contributions of the present work is the discussion on the non-neutrality of 'neutral' facial expressions and how this non-neutrality may have affected the measure of the ability to discriminate happy or angry from 'neutral' facial expressions. These results are based on the NimStim stimulus set (Tottenham et al., 2009) that was used in the present dissertation. This set of facial stimuli is a standardized set of stimuli and has been used in varying types of research publications. With this said, caution should be made in generalizing the questionability of neutral facial expressions to other stimulus sets, in that the results presented here are based on only one stimulus set. However, one may assume that this can be generalized in that the non-neutrality of facial expressions has been previously discussed in the literature in which other stimulus sets have been used (e.g., Carrera-Levillain & Fernandez-Dols, 1994; Lee et al., 2008).

Secondly, the manner in which the original *d*' values were adjusted in Studies II and III may not necessarily be the most appropriate method of adjustment. It was assumed that, other things being equal, the *d*' values for each emotion-face type is proportional to the perceived dissimilarity of the emotional and the neutral stimulus, and that this dissimilarity can be estimated (cf. Dunn, 1983) by their Euclidean distance (*ED*) in the space defined by the three scales of Anger (Scale A), Happiness (Scale H), and Emotionality (Scale E). Adjustments based on alternative models of dissimilarity might have been tried, perhaps based on multidimensional scaling (cf. Russell & Bullock; 1985).

If the scale ratings had reflected exactly the same effects (happy-superiority, non-neutrality of 'neutral, etc.) as the *d*' values, then, theoretically, all the adjusted *d*' values might have been equalized. However, this did not happen. In Study II, the happy-superiority effect decreased, and the angry-female faces remained more difficult to detect than happy and angry-male faces. Thus, an angry-female disadvantage remained. As in Study III, the results from the adjustments in Experiment 1 showed more of a male advantage, with happy-female values nearing the values of the male faces, while the angry-female faces remained at a disadvantage. Whereas, for the adjustment in Study III, Experiment 2, the happy-superiority effect was shown with a male advantage for angry faces only, and again, the angry-female disadvantage remained.

Therefore, it is possible that in detection of emotion, participants may have used cues other than when rating the intensity of the emotions. For example, it has been suggested that gender recognition is based mainly on the scanning of the upper regions of the faces (e.g., Joyce, Schyne, Gosselin, Cottrell, & Rossion, 2006), and emotional recognition is based mainly on the scanning of the lower regions of the face (e.g., Smith et al., 2005). In the case of the present dissertation, the task was to detect emotion (Study I & Study II, Experiment 1) or the specific emotion (Study III, Experiment 2), as well as rate the stimuli on the specific emotion type and emotionality (Studies II & III). Thus, the participants may have focused mainly on the lower regions of the face where emotion is primarily scanned.

Additionally, it has also been suggested that angry faces are scanned more in the eye region (e.g., Calvo & Nummenmaa, 2008), and that happy faces are scanned more in the mouth region (e.g., Calvo & Nummenmaa, 2008; Leppänen & Hietanen, 2004, 2007, Smith et al., 2005). Combining these different scanning styles, participants here may have been mainly focusing on the lower regions of the face (emotion detection) disregarding, to some extent, the upper regions of the face (gender and anger detection) and thus a happy (lower region) -superiority effect was consequently created.

Thirdly, it must be pointed out that only angry and happy faces were used and detected among neutral facial expressions. To begin with, there is a strength in using only angry and happy faces as the *target* faces in that it reduces possible confusion between angry and other negative emotions, such as fear, for example. Although this is a strength, there is a precaution that should be considered. In the more commonly used categorization/recognition tasks, the participant categorizes the emotions as a specific emotion type or says which emotion is being displayed. In the present dissertation, this type of categorization was not used. Participants were given specifically instructions to detect emotion or detect the specific emotion of anger and happiness; they did not themselves say which emotion they thought was being displayed, and not all things were as simple as *black* and *white*, *one* or *the other*. Thus, in some cases, there may have been participants who thought that a particular neutral face displayed emotion, not a lack of emotion, and therefore, answered *yes* the face was emotional although they categorized it as ‘neutral’. The particular face in question may well have been, according to the participant, an emotional face and not lacking en emotional expression.

This point can be seen when comparing the results of Study I and Study III, Experiment 2. The *d*' values for happy faces in Study I approached approximately 2.5 and the *d*' values for the happy-detection group in Study III, Experiment 2, approached approximately 4. In Study I, participants were to detect emotion, while in Study III, Experiment 2, participants were to specifically detect happiness. With such a difference in the *d*' values in the two studies, participants may have perceived emotion in both the happy and in some neutral faces in Study I, while in Study III, Experiment 2, participants may have perceived happiness only in the happy faces, which was the specific task.

Future Research

As often said, hindsight is 20/20, and how true this is. When looking back upon the research conducted for this dissertation many ideas come flooding in, now that the results are in, of what could have been done, what should have been done, and what could be done in the future. In this section, however, four ideas of future research will be suggested, in following what was discussed in the above Implications and Points of Caution.

Firstly and as was mentioned previously, there is mixed evidence supporting both angry-superiority and happy-superiority effects within visual search tasks (e.g., Hansen & Hansen, 1988; Juth et al., 2005; Öhman et al., 2001, Öhman et al., 2010). Although this discrepancy has been investigated previously (Öhman et al., 2010), further investigation could help shed more light onto the discrepancy. Given the results in the present dissertation, one potential continuation of the present project might, therefore, be to investigate whether a happy-superiority effect emerges when happy faces are presented in an array of other emotional facial expressions in a signal-detection design. This may be quite an undertaking given that one must account for each of the variables in order to have an equal number of trials per condition. In terms of signal detection, the number of trials needed per condition would increase exponentially and could become quite demanding for the participant. However, the fact that the results found in Study I are based upon participants who returned and completed the experiment for four different sessions indicates that this task would not be necessarily impossible to complete. This could shed light regarding whether happiness or anger takes precedence in a visual search task experimental design, specifically.

Secondly, as was mentioned in the first point of caution, only one stimulus set was used in the present dissertation; therefore, the results regarding the non-neutrality of 'neutral' facial expressions may not be able to be generalized to other stimulus sets. It may be, therefore, fruitful to perform the same type of rating as was performed here, thus validating the present work, as well as other stimulus sets.

Thirdly, the discussion on the scanning differences in searching for facial cues to gender (scanned mainly in the upper regions of the face) and emotion (scanned mainly in the lower regions of the face) could be addressed. As was performed in Studies I and III (and, in part, Study II), the task was to detect emotion or a specific emotion. Therefore, participants may have been focusing mainly on the lower region of the face (emotion and happiness detection), and, in part, may have been disregarding the upper region of the face (gender and anger detection). This may have, unintentionally, created the happy-superiority effect presented here.

The focus of the studies presented here was on emotion and not on gender of the face in that the task was not to detect a male or female face or rate the faces on maleness or femaleness, but, rather, to detect emotion or rate the faces on emotionality. In following the design of Studies I, II, and III, one option to validate whether an angry-superiority effect would emerge could be to ask participants to detect, or recognize, gender. If indeed the gender cues are scanned mainly in the upper regions, then possibly an anger-superiority effect may emerge in that participants may be mainly focusing on the upper regions of the face (gender and anger detection). Potentially, this could be examined further in an eye-tracking experiment so that the actual scanning of the facial stimuli by the participants could be measured.

Fourthly, the task in Study III, Experiment 2, was to detect the specific emotion (angry, happy) separately in a between-groups design. However, with hindsight, a third group could have been added with the task to detect the neutral facial expression. If, as shown in Studies II and III, 'neutral' faces are not neutral, and, as previously mentioned (Carrera-Levillain & Fernandez-Dols, 1994; Shah & Lewis, 2003), a neutral facial expression is in their own right an expression, then possibly it is worth detecting neutrality as it is to detect emotion, happiness, or anger. This may reverse a possible anchor effect so that happy faces are not compared to neutral, but rather, neutral faces compared to happy faces. Hence, the distance between happy and neutral may decrease.

Final Words on the Matter

In final, regardless of the gender of the viewer, happiness takes precedence, an effect that was greater for female faces than for male faces, thus, possibly women are expected to look happy and not angry. Although the findings presented here are robust, as is known in the scientific community, one must consider all aspects of the experimental situation.

The present dissertation gives empirical evidence of how stringent examination of ones research can result in differing results, even when this is achieved by only modifying a specific aspect of the question at hand. In conclusion, given all things presented here, the present dissertation demonstrates how methodology, contextual factors, and the particular stimuli used affect results. All of which play a role in the evaluation of emotional facial expressions, and most profoundly, neutral facial expressions may not be, indeed, so very neutral. It may be, on the other, as Aristotle said, “Happiness is the meaning and purpose of life, the whole aim and end of human existence,” and if one is happy, then happiness in others may be more easily perceived; therefore, happiness may indeed and should take precedence.

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The human face is the organic seat of beauty.

It is the register of value in development, a record of Experience, whose legitimate office is to perfect the life, a legible language to those who will study it, of the majestic mistress, the soul.

-- Eliza Farnham
American Author and Social Reformist