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EMOTION DISCRIMINATION IN PERIPHERAL VISION

A Thesis
Presented to
The Faculty of the Department of Psychological Sciences
Western Kentucky University
Bowling Green, KY

In Partial Fulfillment
Of the Requirements for the Degree
Master of Science

By
Hayley M. Lambert

May 2018

EMOTION DISCRIMINATION IN PERIPHERAL VISION

Date Recommended April 5, 2018

Andrew Mienaltowski, Director of Thesis

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Dean, Graduate Studies and Research 4/19/18 Date

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Department of Psychological Sciences Western Kentucky University

The recognition accuracy of emotion in faces varies depending on the discrete emotion being expressed and the location of the stimulus. More specifically, emotion detection performance declines as facial stimuli are presented further out in the periphery. Interestingly, this is not always true for faces depicting happy emotional expressions, which can be associated with maintained levels of detection. The current study examined neurophysiological responses to emotional face discrimination in the periphery. Two event-related potentials (ERPs) that can be sensitive to the perception of emotion in faces, P1 and N170, were examined using EEG data recorded from electrodes at occipito-temporal sites on the scalp. Participants saw a face presented at a 0° angle of eccentricity, at a 10° angle of eccentricity, or at a 20° angle of eccentricity, and responded whether the face was a specific emotion or neutral. Results showed that emotion detection was higher when faces were presented at the center of the display than at 10° or 20° for both happy and angry expressions. Likewise, the voltage amplitude of the N170 component was greater when faces were presented at the center of the display than at 10° or 20°. Further exploration of the data revealed that high intensity expressions were more easily detected at each location and elicited a larger amplitude N170 than low intensity expressions for both emotions. For a peripheral emotion discrimination task like that which was employed in the current study, emotion cues seem to enhance face processing at peripheral locations.

Introduction

Previous emotion-oriented research on detecting and identifying features of faces in peripheral vision has shown that it becomes harder to detect emotion in faces as they are presented further away from the foveal region of our visual field (Calvo, Fernández-Martín, & Nummenmaa, 2014). Faces presented at these greater angles of eccentricity in the periphery can be identified with less difficulty in one case: when the participant has been asked to determine if the face is happy or not. In that case, performance is preserved at larger visual angles from the center of our field of view. This has been found in contrast to the typical experience that we have when parafoveally detecting negative emotions such as fear, anger, and sadness, which become harder to discriminate from neutral faces as they are presented further into the periphery of our field of view. The purpose of the current study was to replicate these findings but also to further explore possible electrophysiological consequences that might be observed using visually-evoked potentials associated with visual attention and face processing.

Recognizing emotions from facial expressions is important for social interaction and for detecting the intentions of others in our environment. Within the visual system, face processing is prioritized through pattern recognition taking place in occipito-temporal regions of the cortex (Kanwisher, McDermott, & Chun, 1997; Maurer, Le Grand, & Mondloch, 2002). Additionally, emotional details on faces, especially when faces are expressing an arousing, negative emotion, receive additional scrutiny by the visual system through parallel channels that are meant to facilitate emotion detection via enhanced attention to emotional features. To detect a face, the configuration of the features is vital. The simple arrangement of two eyes, a nose, and a mouth can activate the fusiform face area in the brain (Maurer et al., 2002). Likewise, reading emotions on the faces of others requires that we are aware of the orientation of facial features relative to one another given the contextual information in which the face is seen.

The fusiform face area, a section of the fusiform gyrus in the extrastriate cortex, is the primary region within which face processing occurs (Kanwisher et al., 1997). There is more activation in this area when faces as opposed to other stimuli are seen (Vuilleumier, Armony, Driver, & Dolan, 2001). Importantly for the study of emotional faces, the amygdala has both inputs and outputs connected to the fusiform face area (Morris et al., 1998). The amygdala preferentially processes emotions, especially negative, allowing for an enhancement of emotional stimuli (Anderson & Phelps, 2001). This is an extremely fast process, as emotional faces differentially activate the amygdala relative to neutral faces within the first 100 ms after presentation (Liu & Ioannides, 2010). Emotion has been shown in many studies to capture attention, as described in a previous literature review by Mohanty and Sussman (2013). This is due to the survival importance inherent to emotion. In situations where survival is at risk, the fast processing of emotional items would be important. Emotion-inducing stimuli such as snakes will rapidly capture attention (Öhman, Flykt, & Esteves, 2001). This attentional capture has the benefit of increasing the ability to detect differences in stimuli rapidly presented after a fearful face (Bocanegra & Zeelenberg, 2011; Phelps, Ling, & Carrasco, 2006), a phenomenon that would be socially important for survival.

Peripheral Emotion Detection

Despite the many interconnected systems of the visual system that support face processing, facial configurations become more difficult to process as the faces are found farther out in peripheral vision. The difficulty of this processing in peripheral vision has traditionally been explained by the distribution of cones within the retina. The portion of the eye which processes the center of the visual field consists of a tight cluster of cone cells referred to as the fovea (Curcio, Sloan, Kalina, & Hendrickson, 1990). Because of this clustering, the fovea has a high level of visual acuity. The density of the cone cells decreases and the spacing between cone cells gets larger with increasing distance from the foveal region of the retina (Curcio et al., 1990; Green, 1970), leading to a decrease in acuity and an increase in difficulty perceiving some aspects of stimuli. However, more recent research has suggested that the increase in crowding of stimuli in peripheral vision is another important factor in explaining the difficulty of peripheral perception (Bayle, Schoendorff, Hénaff, & Krolak-Salmon, 2011; Rosenholtz, 2016; Strasburger, Rentschler, & Jüttner, 2011). Distinct parts of an object, such as facial features, become crowded together and are subsequently more difficult to resolve (Bayle et al., 2011; Strasburger et al., 2011). This can be seen most prominently in gender detection tasks, for which success relies on the same types of details as emotion detection, including but not limited to shape of the eyes, mouth, and eyebrows (Brown & Perrett, 1993), but also includes features which lack the attention-grabbing component of emotional valence (e.g., roundness or fullness of face, bone structure, facial symmetry, etc.). Gender detection is often used as a control condition to which one compares emotion detection performance when stimuli are presented in both central and peripheral locations. As faces are moved farther into the periphery, gender detection declines substantially. In fact, at 40° of eccentricity, gender detection can drop to near chance levels (Bayle et al., 2011).

Studies look at the implicit effects of emotion on face perception through gender detection tasks in which emotion is manipulated as a feature that is not directly relevant to the participants' responses (Rigoulot, D'Hondt, Honoré, & Sequeira, 2012) or through tasks in which participants simply view the emotional faces passively without making a judgment at all (De Cesarei, Codispoti, & Schupp, 2009; Schupp et al., 2004; Wijers & Banis, 2012). The neurological effects of the presence of emotion on face processing can differ based on whether the task instructions ask participants to implicitly or explicitly process emotion (Rellecke, Sommer, & Schacht, 2012). Explicit effects are studied in many different formats. For instance, in forced-choice reaction tasks, participants respond with one of two or more options. These tasks usually simply involve a categorization between an emotional and a neutral/non-emotional option. Here, too, recognition performance (e.g., percent accuracy or discriminability values) declines at higher angles of eccentricity. Negative emotions are less accurately categorized as the angle of eccentricity at which the stimulus is presented increases (Calvo, Fernández-Martín, & Nummenmaa, 2014). However, decline in emotion discrimination at larger angles of eccentricity is less steep than the decline observed in gender detection when participants view the very same facial stimuli (Bayle et al., 2011; Rigoulot et al., 2011).

Happiness as an Exceptional Case

Although this decline is usually still observed even when stimuli are presented in the near periphery, one emotion stands out as being exceptionally detectable. At close angles of eccentricity such as 5°, happy faces were as accurately detected as when they were centrally presented (Calvo, Fernández-Martín, & Nummenmaa, 2014). This was not found for negatively valenced emotions such as fear, anger, or sadness, which displayed a decline in performance. Interestingly, a recent finding from the work of Calvo and colleagues has generated an explanation for happiness serving as an exception to the expectation of eccentricity-related decline in emotion detection performance. Rather than focusing on the emotional aspect of a happy face, participants focus on specific perceptual features that act to preserve happy face detection performance. Negative emotions require more time to interpret than happiness due to shared configurations of the eyebrow, nose, and mouth. Oftentimes one must integrate the emotion cues from multiple face regions to successfully classify a face as containing a negative emotion. In contrast, happy faces can generally be distinguished by the smile, reducing one's focus to the mouth region in order to maintain accurate responding. Across emotional face sets that are available to scientists, this outcome is likely to be most true for happiness because it is usually the lone positively valenced stimulus category used. When examples of multiple categories of discrete negative emotions are included, disambiguation may require interpreting cues in both the eye and mouth regions.

Initially, this explanation emerged from a study that showed that happy faces facilitated the detection of pleasantness within stimuli depicting emotional scenes (Calvo, Nummenmaa, & Avero, 2010). Participants were presented with a prime face at about 2.5° from the center of the display followed by a picture of a scene that participants then categorized as pleasant or unpleasant. Happy faces led to no reaction time benefit when categorizing the emotional scenes as pleasant or unpleasant at a 250 ms inter-stimulus interval, but an effect was observed for an inter-stimulus interval of 750 ms. The authors suggest that the unique facial features of happy faces are rapidly processed and prime subsequent emotion-congruent judgments but only after enough time has passed for the emotional valence related information to be interpreted and categorized. Other emotions failed to produce this same priming effect, suggesting that happy faces are processed more quickly than other expressions. Following this, Calvo and colleagues examined the various physical components of a face in relation to their importance for emotion recognition in happy faces. They were seeking more direct evidence of the benefit that the unique combination of facial features used for characterizing happiness conferred a detection advantage for happy expressions that were displayed at increasing angles of eccentricity into the periphery than those features of other emotions. Calvo, Fernández-Martín, and Nummenmaa (2014) found that when just the mouth area of a happy face was displayed peripherally, participants were just as skilled at detecting happiness as when they were evaluating a complete happy face. Moreover, high levels of performance were maintained as the happy facial stimuli were presented at greater angles of eccentricity into the periphery relative to other faces (i.e., surprised, disgusted, sad, angry, and fearful). This was not true for the stimuli that merely consisted of the eye region of happy faces, which were instead harder to categorize.

Based on these findings, the researchers suggested that the smile on a happy face is perceptually "unique." Negative faces have similar face feature composition to one another – scrunched nose, furrowed eyebrows, and a down-turned mouth – and are thus harder to distinguish from one another, leading to longer reaction times and poorer accuracy (Calvo & Beltrán, 2013). In contrast, a smile is specific to a happy face. If a smile is perceived, there is no other emotion that could be a reasonable alternative to happiness, leading to quicker and more accurate categorization. Although there are many different emotions one may feel throughout their lifetime, perception of these emotions in peripheral vision seems to rely on whether the features of emotional expressions are particularly salient or not, as is the case with the unique features of happy expressions.

Neurophysiological Correlates of Facial Emotion Perception

The behavioral evidence for the greater ease of detection of happy faces can be further elaborated upon by using neurophysiological measures of stimulus perception. One method for examining the neurocorrelates of the perceptual boost that emotional features might give to facial images would be to use event-related potentials (ERP) to examine responses of the visual system to the onset of emotional expressions. ERPs reflect segments of electrical activity collected within an electroencephalogram (EEG) recorded by electrodes placed on the scalp of participants. A participant's brain activation in response to stimuli is time-locked to specific portions of the task, such as the stimulus presentation or the participant's response. The waveforms measured by the EEG are aggregated together for each participant as a function of experimental condition via segmentation and averaging. The peaks and troughs of the resulting average segment are examined at the specific time points of interest and from specific electrode clusters to inspect differences in amplitude or latency across conditions that reveal attentional and perceptual phenomena.

With respect to examining the impact of emotion on face perception, the current study investigated two components of visually-evoked potentials that emerge to the onset of facial images. The first component of interest was the P1, a positive-going component that occurs about 100 ms after a stimulus is presented. Evidence suggests that the P1 is an index of selective attention (Brosch, Sander, Pourtois, & Scherer, 2008; Wijers & Banis, 2012), especially in peripheral vision. The P1 is a measure of sensory gain control

(Handy & Khoe, 2005). It is thought to be generated by the extrastriate cortex and thus is measured on occipital regions of the scalp (Clark, Fan, & Hillyard, 1995; Rigoulot et al., 2008). The P1 component has been found to have an enhanced positivity when emotional facial expressions are presented compared to neutral ones (Batty & Taylor, 2003; Rellecke et al., 2012).

The second visual component of interest was the N170. The N170 is, as the name suggests, a negative-going component about 170 ms after a face stimulus presentation. The N170 is a signal of face processing, measured at occipito-temporal sites on the scalp and may be generated by the fusiform gyrus (Bentin, Allison, Puce, Perez, & McCarthy, 1996; Halgren, Raij, Marinkovic, Jousmäki, & Hari, 2000; Maurer et al., 2002; Towler & Eimer, 2015). How N170 is affected by the emotion of facial stimuli is still under scrutiny, as findings have been equivocal (Calvo & Beltrán, 2013; Tamamiya & Hiraki, 2013). Tamamiya and Hiraki (2013) found larger amplitudes for angry faces compared to happy or neutral faces, and more accurate recognition for angry faces than happy in a centrally presented recognition task. Calvo and Beltrán (2013), on the other hand, used a similar centrally presented categorization task, where participants would agree or disagree with a probe emotional word after presentation of a face. The authors found larger amplitudes for negative faces than for neutral faces, with happy faces not differing from either. Additionally, their behavioral results showed far better accuracy and faster reaction times for happy faces. This may, however, reflect differences in the tasks or cultural differences in the populations being sampled, as Tamamiya and Hiraki used a sample of Japanese students while Calvo and Beltrán used a sample of Spanish students.

In our own work, happy and angry faces have led to enhanced N170 amplitudes relative to neutral faces when stimuli are presented centrally on a display (Chambers, 2015).

Although they measure different processes, the P1 and the N170 both experience more extreme amplitudes in the right hemisphere than in the left in response to faces (Bentin et al., 1996; Tamaiya & Hiraki, 2013; Towler & Eimer, 2015; Wijers & Banis, 2012). This lateralization is attributed to the right hemispheric location of the fusiform face area, which, as noted previously, selectively activates when presented with faces (Kanwisher et al., 1997). In some studies, this right hemisphere lateralization has been found to be enhanced in response to emotional faces as opposed to neutral (Batty & Taylor, 2003; Calvo, Beltrán, & Fernández-Martín, 2014; Wijers & Banis, 2012). This lateralization has not been frequently studied in conjunction with non-central presentations; however, it is possible that the lateralization of face processing may lead to differential enhancements in visually-evoked potentials based on the hemisphere over which an electrode is located or given that stimuli become increasingly represented by one visual field over the other (e.g., left over right) as stimuli appear at larger angles of eccentricity from the center of the display.

The current study extended previous research in three important ways. First, this study examined visually evoked potentials to faces presented at multiple angles of eccentricity (0°, 10°, and 20°) as well as participant accuracy when categorizing facial emotion. Many previous ERP experiments used faces presented either centrally or at angles of eccentricity less than 5° (Calvo et al., 2010; Calvo & Beltrán, 2013; Calvo, Fernández-Martín, & Nummenmaa, 2014; Tamamiya & Hiraki, 2013; Wijers & Banis, 2012). Few studies have presented stimuli as far out as 20° (e.g., Bayle et al., 2011).

Second, the two emotions used in this study were blocked in separate tasks along with neutral faces. Previous research has frequently combined emotional faces of difference valences in the same task and/or block of trials (Calvo & Beltrán, 2013; Calvo, Beltrán, & Fernández-Martín, 2014). Finally, this study followed the more commonly used procedure for forced-choice categorization. After the face presentation, Calvo, Beltrán, and Fernández-Martín (2014) would display a probe word consisting of one of the five emotions used in their task. Participants would then respond if the face was the same emotion as the probe word by pressing the "Yes" key or if it was not that emotion by pressing the "No" key. This is a forced-choice task, but it is unclear when participants respond "No" whether they did so because they believed the face to be another emotion or if they simply were unsure if it was the same as the probe word. In this study, the two response options were the more standard "neutral" and either "happy" or "angry" depending on the task. This change allowed behavioral data to be analyzed for accuracy and sensitivity of discrimination between the emotional and neutral faces. These data were then compared to the neurological data from the ERP components, as there have been discrepancies between behavioral and neurophysiological results in previous studies (Calvo & Beltrán, 2013; Tamamiya & Hiraki, 2013).

Hypotheses

1) Behaviorally, detection of emotional faces, as operationalized by their discriminability from neutral faces, will be greater in the happy/neutral task than the angry/neutral task at each angle of eccentricity.
2) Discriminability of emotion in faces as indexed psychophysically with d', or discrimination scores, should decline with increasing angle of eccentricity.

3) Peak amplitudes of the P1 and N170 components will be greater for the emotional faces than for the neutral faces.
4) Peak amplitudes of the P1 and N170 components will be attenuated at higher angles of eccentricity, but attenuation may very well be greater for angry faces than happy faces.
5) Peak amplitudes of the P1 and N170 components will be greater when measured using electrodes over the right hemisphere compared to electrodes over the left hemisphere for emotional faces than for neutral faces. Additionally, this difference in peak amplitude as a function of electrode location might be more noticeable at higher angles of eccentricity.

Method

Participants

Twenty-one undergraduate participants (11 women, 10 men) between the ages of 18 and 27 (*M* = 19.57, *SD* = 1.99) from Western Kentucky University consented to take part in this experiment. They received course credit and a $10 gift card for their participation. All participants had normal or corrected to normal vision (visual acuity in Log MAR: *M* = -.035, *SD* = .10).

Materials

Participants completed a depression screening, an anxiety screening, a neuropsychological screening, a handedness questionnaire, a personality questionnaire, a visual acuity test, a lab demographics questionnaire, the peripheral emotion detection tasks, and an emotion judgment and intensity rating task. Screens and personality measures were included to be able to characterize the sample recruited for the study.

Table 1 includes the means and standard deviations for these measures, all of which are described after the main tasks for the study.

Table 1
Individual Differences Measures

Measure	*M*	*SD*
Age (in years)	19.57	1.99
CES-D (max 80)	35.67	9.70
GAD-7 (max 21)	6.65	4.67
BAS Drive (max 16)	8.76	2.34
BAD Fun-Seeking (max 16)	7.33	2.08
BAS Reward-Responsiveness (max 20)	7.76	2.19
BIS (max 28)	13.91	4.24
Visual Acuity (in log MAR)		
-20 degrees	0.96	0.12
-15 degrees	0.91	0.15
-10 degrees	0.80	0.12
-5 degrees	0.61	0.24
0 degrees	-0.03	0.08
5 degrees	0.62	0.23
10 degrees	0.78	0.22
15 degrees	0.92	0.22
20 degrees	0.97	0.11

Note: One participant did not complete the GAD-7 (n =20).

Peripheral Emotion Detection Task. Participants were presented with facial stimuli at various angles of eccentricity one at a time. The emotional stimuli were presented in two different versions of the same task. In the angry/neutral task, facial stimuli had either an angry or a neutral expression, and, in the happy/neutral task, facial stimuli had either a happy or a neutral expression. The order of these tasks was counterbalanced. Participants were asked to respond after each face to indicate whether that face had a neutral expression or the emotional expression shown in the task. Participants were asked to guess if they are unsure of the emotional content of a given facial stimulus.

Pictures of faces were taken from the NimStim Face Stimulus Set (Tottenham et al., 2009) and the Karolinska Directed Emotional Faces Set (Lundquist, Flykt, & Öhman, 1998). There were 72 faces used in this experiment: 12 for each gender (male and female) and emotion (anger, happy, and neutral). All faces were placed within an oval on a black background to remove distracting features such as hair and clothing. The stimuli covered a visual angle of 5.4° wide x 7.6° high. Each stimulus within each condition was presented at all of the five possible locations in a random presentation order. The trials were displayed on an ASUS 24-in. 1920 × 1080 full HD LCD monitor with a 144Hz rapid refresh rate.

Overall, participants completed 480 trials for each emotion detection task, so 960 total trials. There were 48 emotional and 48 neutral trials at each of the five angles of eccentricity. Half of the trials depicted male targets and half depicted female targets, and each target face was presented twice. Each task was broken down into 4 blocks of 120 trials. Each trial type for a given task (i.e., emotion x eccentricity) was randomly distributed across blocks. At the start of each trial, a fixation cross appeared at the center of the screen for between 500-700 ms. Next, a face was presented for 150 ms at one of five locations: at fixation, at 10° to either the left or right of fixation (-10° or +10° respectively), or at 20° to either the left or right of fixation (-20° or +20° respectively). The specific location of the stimulus on the display was random. By presenting a face to the left hemifield on 40% of the trials and to the right hemifield on 40% of the trials, it was possible to isolate the differences in emotion detection between hemispheres, as the N170 component shows hemispheric differences (e.g., greater amplitude for right hemisphere electrodes than for left; Towler & Eimer, 2015). After the facial stimulus disappeared, a response screen with reminders of the correct button for each response appeared for 1,000 ms during which time participants pressed a button to indicate whether the face was an emotional face – angry or happy depending upon condition – or a neutral face. Finally, when either the participant responded or 1,000 ms had passed, the trial ended and the next trial immediately began. Participants were not given feedback about the accuracy of their response. Please see Figure 1 for a sample trial.

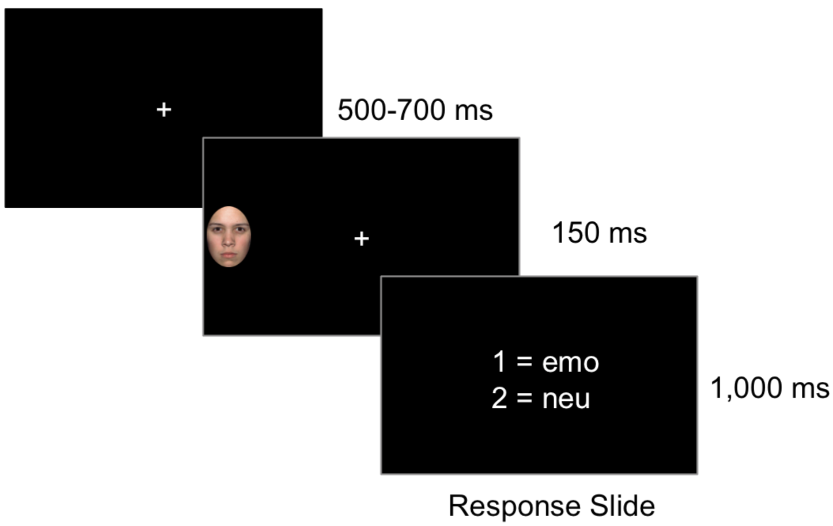

Figure 1. Order of events within a given trial of the peripheral emotion detection task.

Emotion Judgment and Intensity Rating Task. Following completion of both peripheral emotion detection tasks, participants completed two rating tasks. In each of these tasks, a face stimulus was presented in the center of the screen until the participant responded. All face stimuli used in the peripheral emotion detection tasks were presented once per task in a random order. In the emotion judgment task, participants indicated whether they believed the face had an angry, happy, or neutral expression. In the emotion intensity rating task, participants rated each face on a 4-point Likert scale to indicate the intensity of emotion displayed regardless of the valence of the emotion. A 1 indicated no emotion is expressed on the face, a 2 indicated low intensity emotion, a 3 indicated medium intensity emotion, and a 4 indicated high intensity emotion. These data were used to determine if there was an impact of the perceived intensity of the emotional faces used on their discriminability or the ERP components, and are reported as part of exploratory results below.

Individual Difference Measures. Data from many individual difference measures were collected to be able to characterize the sample for the current study. Specific hypotheses were not formulated a priori for how performance on these measures might relate to emotion perception performance. Below is a description of each measure included.

Center for Epidemiological Studies Depression Scale (CES-D). This is a 20-item scale (see Appendix A) used to screen participants for symptoms of depression (Radloff, 1977). Participants use a 4-point Likert scale to indicate the extent to which they have displayed a variety of symptoms of depression (e.g., *During the past week, I felt that I could not shake off the blues even with help from my family or friends.*) over the course of the past week: from *a. Rarely or none of the time (less than one day)* to *d. Most or all of the time (5-7 days)*. Composite scores are calculated by adding the responses to all 20 items into one score. The internal consistency of the measure is .85.

Generalized Anxiety Disorder Scale (GAD-7). This is a seven-item scale (see Appendix B) used to screen participants for anxiety symptoms associated with Generalized Anxiety Disorder (Spitzer, Kroenke, Williams, & Löwe, 2006). Participants use a 4-point Likert scale to indicate the extent to which they are displaying symptoms (e.g., *Worrying too much about different things*) of general anxiety: from *0. Not at all* to *4. Nearly every day*. Composite scores are calculated by adding the responses to all 7 items into one score. The internal consistency of the measure is .92.

Neuropsychological Screening. This screening is used to gather information on the participants' medical history that may affect the quality of the EEG data collected. Participants answer 13 yes or no questions (see Appendix C) and provide explanations to answer questions answered with yes. Additionally, they provide information about any medications or supplements that they are taking.

Brief Edinburgh Handedness Inventory. This is a 10-item measure (see Appendix D) used to assess the extent to which a participant is predominantly left or right-handed (Oldfield, 1971). It is unclear if handedness would impact the design of this experiment, so this measure allows for a simple examination of handedness as a covariate.

BIS/BAS Scale. This 20-item scale (see Appendix E) was used to examine individual differences in approach and avoidance tendencies (Carver & White, 1994). It is also unclear if these tendencies will impact the design of the experiment, so this measure allows for each dimension to be treated as a possible covariate. The scale is broken down into 4 dimensions: BIS, BAS Fun-seeking, BAS Drive, and BAS Reward responsiveness. Internal consistency for each dimension is as follows: BIS = .76, BAS Fun-seeking = .60, BAS Drive = .74, and BAS Reward responsiveness = .70.

Central Visual Acuity Test. A Colenbrander 1-meter chart test was used to determine each participant's visual acuity while looking straight ahead (at 0°). Participants stood one meter away from a chart containing twenty lines of capital letters of decreasing size. The participant read the lowest line on the chart for which they can clearly read all the letters. Their result provided a Snellen fraction based on the line read that was log-transformed into its minimum angle of resolution (logMAR).

Peripheral Visual Acuity Test. A Colenbrander 1-meter chart was used as a measure of each participant's visual acuity in the periphery. Participants stood one meter away from a chart containing twenty lines of capital letters of decreasing size. The participant would focus on a fixation point straight ahead and read a letter from the chart using their peripheral vision. The experimenter covered up all but one letter of the chart at a time, starting with the largest size and moving down one size for each correct response. When the participant responded incorrectly, the chart was moved to the next presentation location. The chart would be placed at 20° eccentricity on the right or left side first, then the other side at 20°, then each side again at 15°, and so on by 5°. This test was always presented before the central visual acuity test to control for participants remembering the chart from the central test. All scores are reported in term of log MAR.

Lab Demographics Questionnaire. This questionnaire (see Appendix F) was used to determine whether the sample of participants in this study is representative of the population being investigated. Questions include information about participants' age, their highest level of education, their previous jobs, and their ethnic and religious backgrounds.

Procedure

Upon arrival, participants were greeted and had the procedure explained to them by the researchers. The participants were asked for their verbal consent. If given, the participant's head was measured to ensure that they could be fitted with the appropriate net. If their head size was within the range of available nets, the researchers marked the vertex of the participant's scalp with a china marker. They were then given the consent form to read and sign. Next, participants completed a series of paperwork that included the measures previously described. Afterwards, participants were seated in the EEG room approximately 57.3 cm from the computer screen where they were fitted with the previously prepared EEG net. Participants were instructed by the researcher to not move any part of their bodies during the experiment, including limiting their blinking, to avoid causing problems with the EEG recording.

The two peripheral emotion detection tasks were presented separately in eight blocks for each task. The presentation order was counterbalanced between participants. Throughout each task, neutral and emotional faces were presented at each of the five locations randomly. Participants were asked to respond by indicating whether the face was neutral or emotional, specifically angry or happy, by pressing a key on the response box. After both emotion detection tasks, the emotion judgment and intensity rating tasks were presented separately. Each of the 72 previously used faces were presented in the center of the screen. Participants were asked to indicate the emotion of the face in the first task and to rate the intensity of the face in the second task by pressing a key on the response box. After all tasks were completed, participants were given the peripheral and central visual acuity tests to screen for normal or corrected-to-normal vision and to collect data on peripheral visual acuity. Those participants who did not have normal or corrected-to-normal vision had their data dropped. Overall, the experiment took a single participant approximately 90 to 120 minutes to complete.

Electrophysiological Recording

Continuous electroencephalograms (EEG) were recorded from a 128 electrode array during the peripheral emotion detection tasks. The left mastoid electrode was used as reference and AFz was used as the ground. Impedance was kept below 50kΩ through wetting the electrode sponges with a solution consisting of potassium chloride, baby shampoo, and distilled water. Signals were filtered by NetStation software with a band pass of 0.03-70 Hz, a notch filter of 60 Hz, and a sampling rate of 250 Hz. The EEG data was corrected offline via the NetStation software for aberrations caused by blinks and eye movements and then double-checked manually. These data were segmented into epochs from -200 to +600 ms relative to stimulus onset timing as confirmed by the E-Prime software. Epochs were discarded if they contained artifacts such as eye blinks or muscle movements, as well as if they contained extreme amplitudes (±200 µV). Segments were averaged together by task at each electrode of interest and the peaks and troughs of the averages were analyzed for the P1 and N170 components. Amplitude and latency values were aggregated and turned into the dependent variables for analysis.

After segmentation and averaging commands were applied to the participants' EEG for each condition (i.e., emotion x task x eccentricity), peak detection was performed using NetStation to identify the peak amplitude and peak latency for each condition. P1 peak detection was restricted to occipito-parietal electrodes over the range of 80-120 ms after stimulus onset (Chambers, 2015; Rellecke et al., 2012). N170 peak detection was restricted to occipito-temporal electrodes over the range of 150-220 ms after stimulus onset (Chambers, 2015; Mercure, Kadosh, & Johnson, 2011; Rellecke et al., 2012). Overall, each participant had values for P1 peak amplitudes and latencies for all 5 angles of eccentricity for neutral, angry, and happy expressions from left, right, and central occipito-parietal electrodes (e.g., electrodes 66, 70, 71, 76, 83, and 84 from 128-electrode high density EGI array). Each participant also had values for N170 peak amplitudes and latencies for all 5 angles of eccentricity for neutral, angry, and happy expressions from left and right occipito-temporal electrodes (left: electrodes 58, 64, 65, 68, and 69; right: electrodes 89, 90, 94, 95, and 96). Please see Figure 2 for the location of the electrodes of interest.

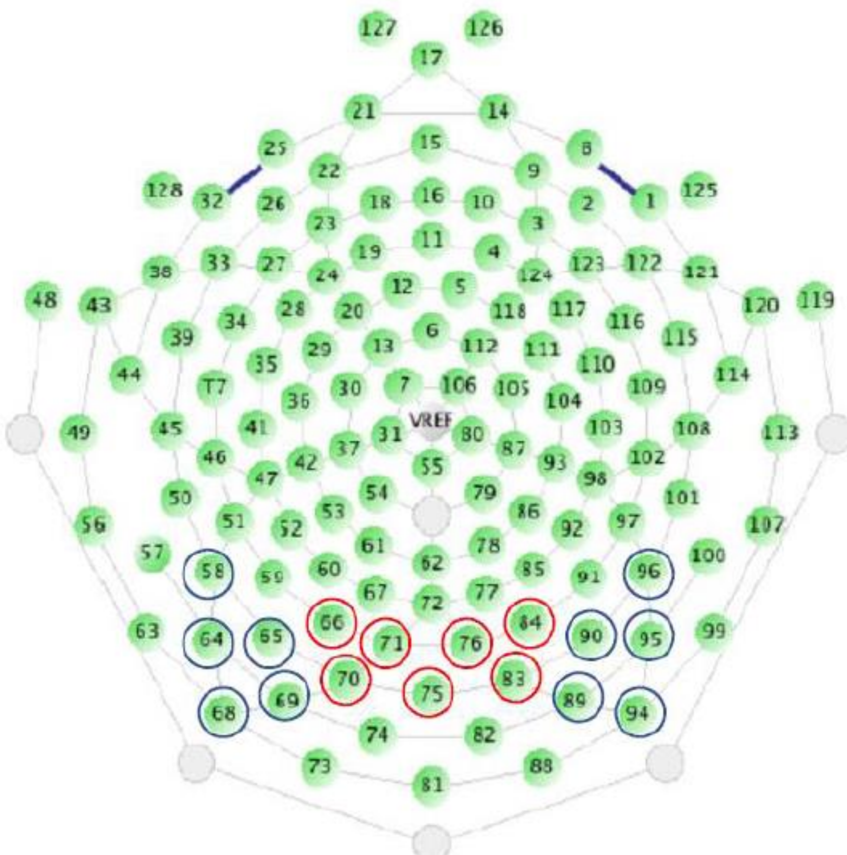

Figure 2. This is a top-down view of the positioning of the electrodes on the participants' head, not to scale, adapted from p. 125 of the Geodesic Sensor Net Technical Manual (Electrical Geodesics, Inc., 2007). The participant is facing the top of the page. The

electrodes circled in red were used to measure the P1 component. The electrodes circled in blue were used to measure the N170 component.

Results

Of the 21 participants who took part in the study, two participants were dropped from the analyses for displaying behavior consistent with not paying attention throughout the task, two displayed excessive eye movements due to not focusing on the center of the display, and one for a mechanical failure of the experimental apparatus. The remaining 16 participants were included in both the analyses of behavioral data and electrophysiological data. The analyses were structured to examine the impact of the manipulated factors within the emotion detection task on behavioral detection and electrophysiological outcomes.

Behavioral Data

Participants' responses on the emotion detection task were processed to calculate hit rates and false alarm rates for detecting emotional stimuli relative to neutral stimuli. For each condition, the resulting hit rate and false alarm rate were transformed to a single d' value by calculating the z-score for each proportion and applying the formula $d' = Z(\text{hit rate}) - Z(\text{false alarm rate})$, consistent with signal detection theory (Macmillan & Creelman, 2005).

Emotion Detection Task. A 2 (Task: angry/neutral and happy/neutral) × 5 (Angle of Eccentricity: -20°, -10°, 0°, 10°, and 20°) repeated-measures ANOVA was conducted on average d' values. There were main effects of both task, $F(1, 15) = 33.28$, $p < .001$, $\eta_p^2 = .69$, and angle of eccentricity, $F(4, 60) = 42.53$, $p < .001$, $\eta_p^2 = .74$, as well as a task × angle of eccentricity interaction, $F(4, 60) = 2.54$, $p = .049$, $\eta_p^2 = .15$. Figure 3 depicts the mean emotion detection performance at each angle of eccentricity for each task. To decompose this interaction, paired-samples *t*-tests were conducted to compare average d' values for the five angles of eccentricity within each task. Performance was significantly better when faces were displayed at 0° (centrally) than at any other angle of eccentricity within the angry task, all *t*s > 6.82, all *p*s < .001, all Cohen's *d*s > 1.70, and within the happy task, all *t*s > 2.88, all *p*s < .001, all *d*s > .72. Performance was significantly better at +10° than at +20° for both the angry task, $t(15) = 5.65$, $p < .001$, $d = 1.41$, and the happy task, $t(15) = 4.46$, $p < .001$, $d = 1.11$. Performance did not differ between -20° and -10° in either the angry task, $t(15) = -.089$, $p = .930$, or the happy task, $t(15) = -1.41$, $p = .178$. Performance also did not differ between -10° and +10° in either the angry task, $t(15) = 03$, $p = .976$, or the happy task, $t(15) =-.252$, $p = .804$. However, performance was better for stimuli presented at -20° than at +20° in the angry task, $t(15) = 4.76$, $p < .001$, $d = 1.19$, and only marginally better in the happy task, $t(15) = -2.07$, $p = .056$. These findings support Hypothesis 2. In general, emotion discrimination performance was as its peak when the stimuli were presented at 0° but then declined as the stimuli were presented further in the periphery. As noted above, this was more so the case for stimuli presented in the right visual field than when they were presented in the left visual field.

The task × angle of eccentricity interaction could also be decomposed by examining task-related differences at each angle of eccentricity, so paired-samples *t*-tests were conducted to compare average d' values for the two tasks at each angle of eccentricity. At all angles of eccentricity except for 0°, performance was significantly lower in the angry task than the happy task, all *t*s > 2.59, all *p*s <.03, all *d*s > 1.15. There was no difference in performance between tasks at the center, $t(15) = -2.00$, $p = .064$. This finding supports Hypothesis 1.

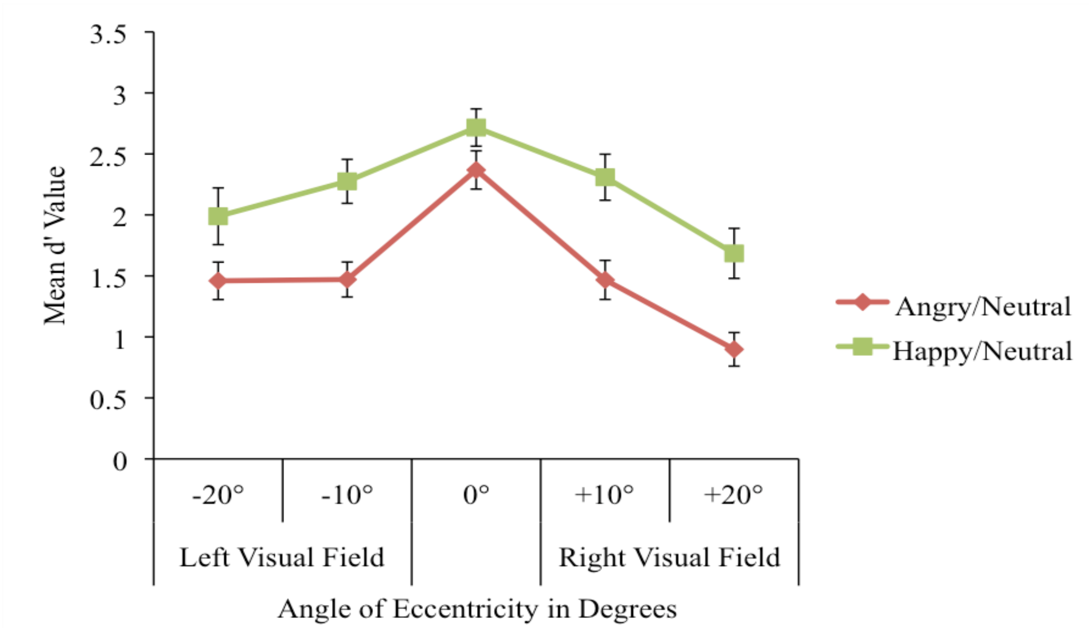

Figure 3. The mean emotion detection performance as measured by d' values at each angle of eccentricity for each task.

Emotion Judgment and Intensity Rating. Mean emotion recognition accuracy values were calculated for each emotional valence using the participants' responses in the centrally presented emotion task immediately following the peripheral detection task. A within-subjects ANOVA conducted to examine the impact of Valence (3: neutral, happy, and anger) on mean accuracy yielded no effect of valence, $F(2, 30) = .27$, $p=.765$. Recognition did not differ whether the face displayed an angry expression ($M = .92$, $SD = .07$), a happy expression ($M = .93$, $SD = .07$), or a neutral expression ($M = .93$, $SD = .07$).

Average intensity ratings were calculated for the three emotional valences of the facial stimuli. Participants had provided ratings using 4-point Likert scale (from *1 = no emotion* to *4 = high intensity*). A within-subjects ANOVA performed to examine the impact of Valence (3: neutral, happy, and anger) on intensity rating revealed a main effect of valence, $F(2, 30) = 405.99$, $p < .001$, $\eta_p^2 = .96$. Post-hoc paired-samples *t*-tests found that faces expressing anger ($M = 3.18$, $SD = 0.37$) were rated as being the more intense than faces expressing happiness ($M = 2.92$, $SD = 0.33$), $t(15) = 2.94$, $p = .01$, $d = .73$, which were each rated as more intense than neutral faces ($M = 1.28$, $SD = 0.28$), $t(15) = 34.34$, $p < .001$, $d = 8.65$, and $t(15) = 23.33$, $p < .001$, $d = 5.87$, respectively.

Electrophysiological Data

For the P1 and N170 analyses, peak voltage amplitudes from the relevant electrodes were averaged together to create hemisphere measures for each component. As mentioned above, for P1, electrodes 66 and 70 were averaged together to create a left hemisphere measure, electrodes 71, 75, and 76 were averaged together to create a central measure, and electrodes 83 and 84 were averaged together to create a right hemisphere measure. For N170, electrodes 58, 64, 65, 68, and 69 were averaged together to create a left hemisphere measure and electrodes 89, 90, 94, 95, and 96 were averaged together to create a right hemisphere measure. On average, for the angry/neutral task, 43-46 segments (89.5-94.9%) were used per participant to calculate peak amplitudes for angry expressions and 43-45 segments (89.5-94.0%) were used for neutral expressions. For the happy/neutral task, 42-45 segments (88.2-94.0%) were used to calculate average peak amplitude voltage for happy expressions, and 42-45 (88.2-94.0%) were used for neutral expressions.

P1 Amplitude. A 2 (Emotion: emotional and neutral) × 2 (Task: angry/neutral task and happy/neutral task) × 5 (Angle of Eccentricity: -20°, -10°, 0°, +10°, and +20°) × 3 (Hemisphere: left, central, and right) repeated-measures ANOVA was conducted on P1 amplitudes. There was a main effect of angle of eccentricity, $F(4, 60) = 22.61$, $p < .001$,

$\eta_p^2 = .601$, and an emotion × angle of eccentricity interaction, $F(4, 60) = 2.63$, $p = .043$, $\eta_p^2 = .149$. Follow-up ANOVAs were conducted to examine the impact of angle of eccentricity separately for emotional and neutral trials. For both emotional, $F(4, 60) = 19.15$, $p < .001$, $\eta_p^2 = .561$, and neutral trials, $F(4, 60) = 20.56$, $p < .001$, $\eta_p^2 = .578$, there was an effect of angle of eccentricity. On emotional trials, least significance difference post-hoc tests revealed a symmetrical decline in P1 amplitude with each incremental increase in visual angle (*p*s < .011), with -10° and +10° and with -20° and +20° each being not significantly different. On neutral trials, least significant difference post-hoc tests demonstrated that P1 amplitude was largest at 0° than at the other locations. Also, there was a steeper decline in P1 amplitude for stimuli presented at -20° than for stimuli presented at +20°; however, P1 amplitudes did significantly decline with each incremental increase in visual angle for stimuli presented on the left and right sides of the display. See Figure 4 for this data displayed graphically and Figure 5 for this data split by task. Overall, these findings fail to support Hypothesis 3 because the voltage amplitude for P1 was not greater for emotional faces than for neutral faces. However, the findings partly support Hypothesis 4 because peak P1 amplitude did decline as stimuli were presented further into the periphery. The decline, though, was not proportionally larger for angry faces than for happy faces as originally predicted. Also note that the data failed to support Hypothesis 5, as no differences were observed in P1 amplitude as a function of cortical hemisphere.

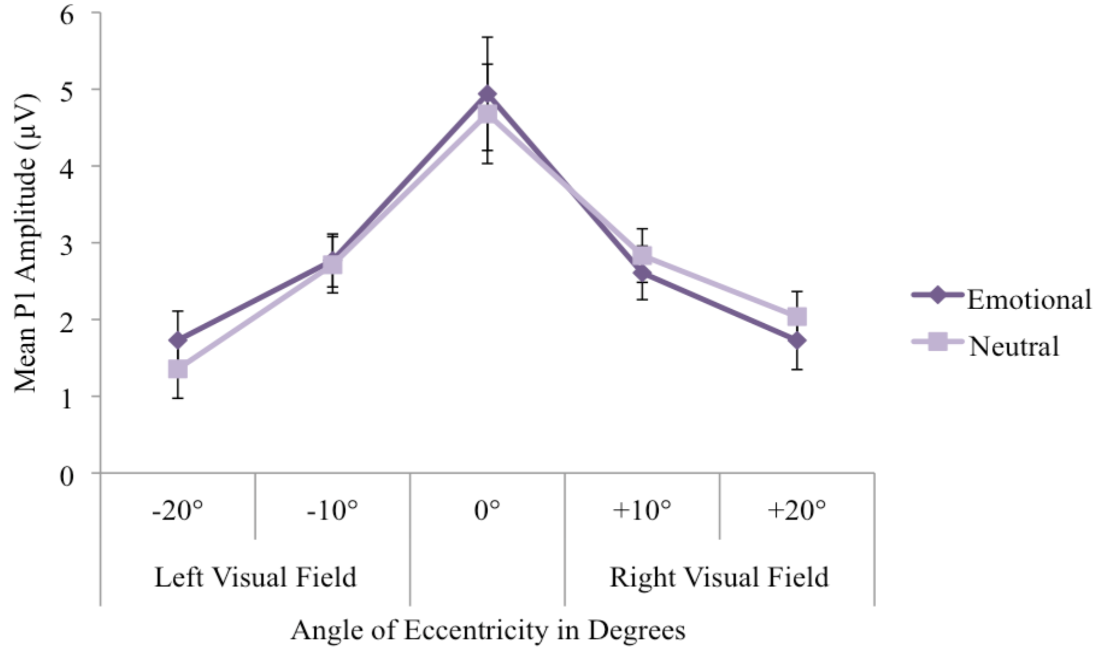

Figure 4. The mean P1 amplitude for emotional and neutral faces at each angle of eccentricity.

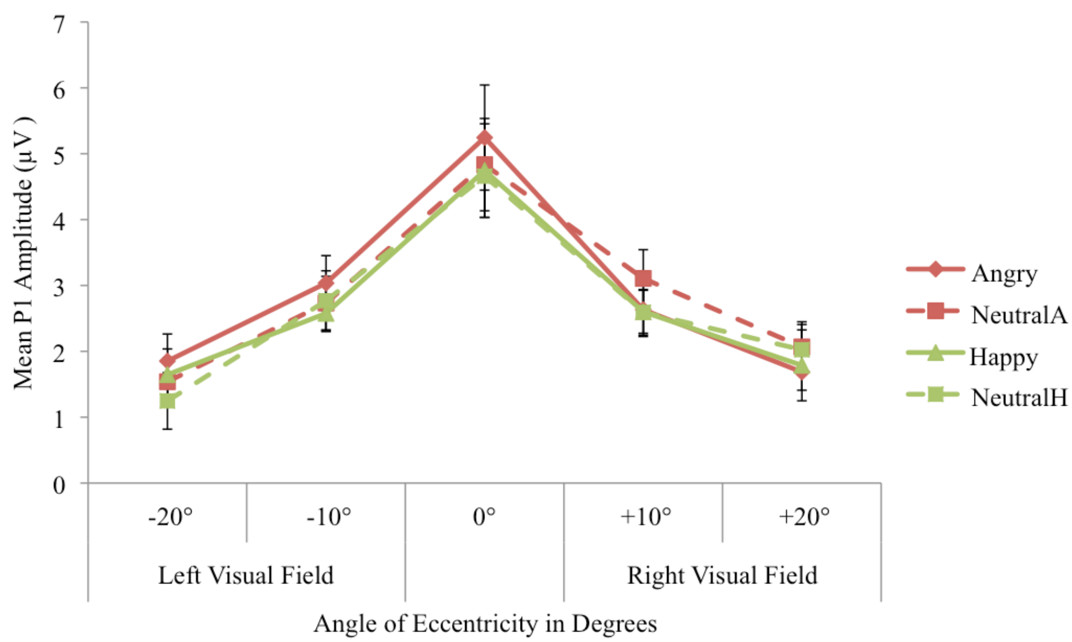

Figure 5. The mean P1 amplitude for faces in the angry and happy task at each angle of eccentricity. Note that although the neutral face data is divided by task, the same neutral faces were used for both tasks.

N170 Amplitude. A 2 (Emotion: emotional and neutral) × 2 (Task: angry/neutral task and happy/neutral task) × 2 (Hemisphere: left and right) × 5 (Angle of Eccentricity: -20°, -10°, 0°, +10°, and +20°) repeated-measures ANOVA was conducted on N170 amplitudes. There was a significant main effect of hemisphere, $F(1, 15) = 4.60$, $p = .049$, $\eta_p^2 = .24$, and a marginal main effect of emotion, $F(1, 15) = 3.43$, $p = .08$, $\eta_p^2 = .19$, as well as task × hemisphere interaction, $F(1, 15) = 6.61$, $p = .021$, $\eta_p^2 = .31$. Emotional facial stimuli elicited a marginally larger amplitude N170 voltage (*M* = -2.62 μV, *SE* = 0.42 μV) than did neutral stimuli (*M* = -2.40 μV, *SE* = 0.38 μV). See Figure 6 for this presented graphically. The task × hemisphere interaction emerged because the difference between hemispheres in the happy task (Left: *M* = -2.17 μV, *SE* = 0.34 μV; Right: *M* = -2.97 μV, *SE* = 0.46 μV) was larger than the difference between hemispheres in the angry task (Left: *M* = -2.22 μV, *SE* = 0.37 μV; Right: *M* = -2.69 μV, *SE* = 0.54 μV). See Figure 7 for this presented graphically. These findings support Hypothesis 3 because N170 voltage amplitude was greater for emotional face stimuli than neutral face stimuli. Hypothesis 4 was not supported as the voltage amplitude of N170 did not vary as a function of the visual angle at which the stimuli were presented on the display. The data also partly support Hypothesis 5 in that there was a voltage amplitude for N170 measured over the right hemisphere was greater than that measured over the left hemisphere.

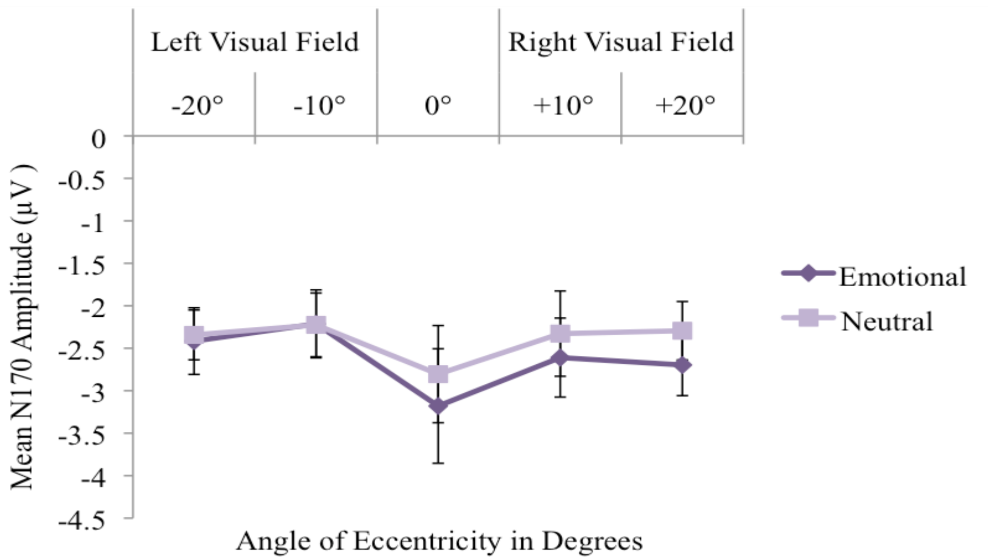

Figure 6. The mean N170 amplitude for emotional and neutral faces at each angle of eccentricity.

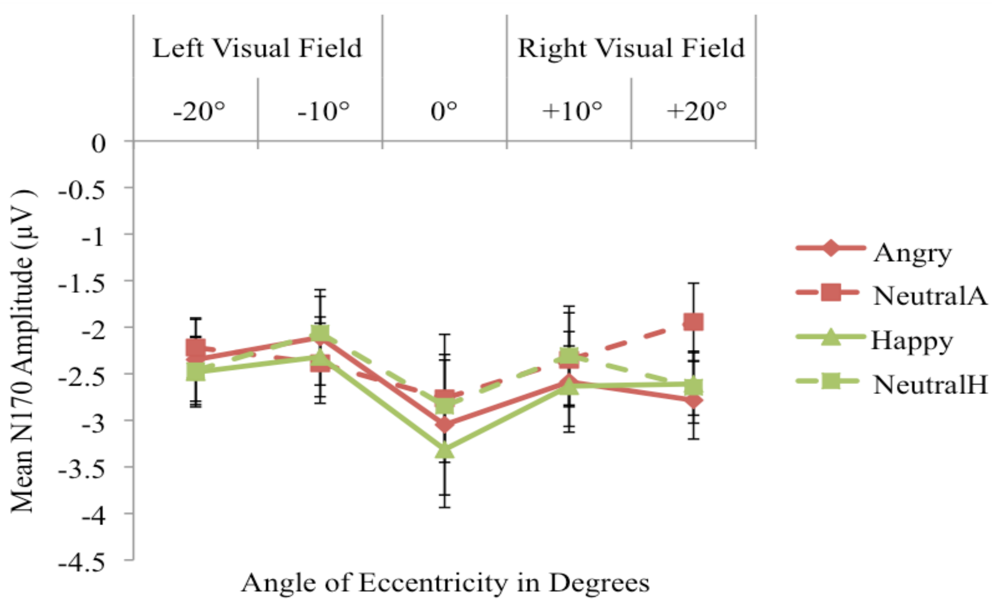

Figure 7. The mean N170 amplitude for faces in the angry and happy task at each angle of eccentricity. Note that although the neutral face data is divided by task, the same neutral faces were used for both tasks.

Exploratory N170 Latency Analyses. Although not initially hypothesized when this study was proposed, prior research has identified that the N170 can be delayed when emotional faces are presented in the periphery (Rigoulot et al., 2011; Rigoulot, D'Hondt, Honoré, & Sequeira, 2012). Therefore, a 2 (Emotion: emotional and neutral) × 2 (Task: angry/neutral task and happy/neutral task) × 2 (Hemisphere: left and right) × 5 (Angle of Eccentricity: -20°, -10°, 0°, +10°, and +20°) repeated-measures ANOVA was conducted on N170 latencies. There were main effects of emotion, $F(1, 15) = 11.5$, $p = .004$, $\eta_p^2 = .43$, hemisphere, $F(1, 15) = 6.59$, $p = .021$, $\eta_p^2 = .31$, and angle of eccentricity, $F(4, 60) = 14.14$, $p < .001$, $\eta_p^2 = .49$, and a marginal task × hemisphere interaction, $F(1, 15) = 4.36$, $p = .054$, $\eta_p^2 = .23$. Least significant difference post-hoc tests were conducted for each of these main effects. For the main effect of emotion, the latency of the N170 was later for emotional faces (*M* = 205 ms, *SE* = 4 ms) relative to neutral faces (*M* = 201 ms, *SE* = 3 ms), *p* = .004. N170 latency was later in the right hemisphere (*M* = 205 ms, *SE* = 4 ms) than in the left (*M* = 201, *SE* = 3 ms), *p* = .021. N170 latency was later at -20° and + 20° than at -10° and +10°, which were all later than at 0°.

Table 2
Mean N170 latencies (ms) by location

Location	*M*	*SE*
-20°	211	4
-10°	202	4
0°	189	5
+10°	203	4
+20°	210	4

Closer inspection of the marginal task and hemisphere interaction revealed that, although there was no difference between latencies in the angry/neutral and happy/neutral discrimination tasks for the right hemisphere, there was a difference in the left hemisphere. The latency of the N170 was later for the angry/neutral discrimination than the happy/neutral discrimination, consistent with previous research by Batty and Taylor (2003). See Table 3 below for these latencies.

Table 3
Mean latencies (in ms) of the Task and Hemisphere marginal interaction.

	Left		Right	
Task	Mean	SE	Mean	SE
Angry/Neutral	203	4	205	4
Happy/Neutral	199	3	206	4

Stimulus-Driven Exploratory Analyses

As mentioned earlier, there were 72 faces used in this experiment: 12 targets from each gender (male and female) and expressing three emotions (anger, happy, and neutral). Faces were divided into high and low intensity within both angry and happy emotion discrimination tasks. These divisions were based on a pilot study consisting of 16 participants. Angry faces were divided into 7 high and 17 low intensity stimuli before the pilot using the criterion that low intensity angry faces would have a closed mouth expression and high intensity angry faces would have an open mouth expression. Participants completed tasks including the emotion recognition and intensity judgment task. A paired-samples *t*-test showed that the high intensity angry faces (M = 3.66, SD = .26) were rated as more intense than the low intensity angry faces (M = 2.53, SD = .39), $t(15) = 15.21$, $p < .001$, $d = 3.80$. Happy faces were examined after the pilot and a similar intensity difference was found based on whether the faces had open or closed mouths. A paired-samples *t*-test showed the seven open mouth happy faces in the pilot (M = 3.47, SD = .57) were rated as more intense than the 17 closed mouth faces (M = 2.55, SD = .48), $t(15) = 7.82$, $p < .001$, $d = 1.96$. Although underpowered given the limited number of trials per participant available to investigate behavioral and electrophysiological outcomes, additional analyses were performed to examine the added impact of expressive intensity (low intensity emotion: 34 trials per cell; high intensity emotion: 14 trials per cell) on the emotion discrimination dependent variables.

Behavioral Data. Average d' values were calculated for each participant for each of the discrimination tasks for high and low intensity stimuli. Note that the participants' responses on 48 neutral trials were used to calculate the false alarm rates that were then combined with hit rates calculated from 34 low intensity emotion trials and then with hit rates calculated from 14 high intensity emotion trials. A 2 (Task: angry/neutral and happy/neutral) × 2 (Intensity: high and low) × 5 (Angle of Eccentricity: -20°, -10°, 0°, 10°, and 20°) repeated-measures ANOVA was conducted on average d' values. There was a main effect of task, $F(1, 15) = 15.53$, $p = .001$, $\eta_p^2 = .51$, intensity, $F(1, 15) = 155.69$, $p < .001$, $\eta_p^2 = .91$, and angle of eccentricity, $F(4, 60) = 34.18$, $p < .001$, $\eta_p^2 = .70$, as well as task × intensity, $F(1, 15) = 70.31$, $p < .001$, $\eta_p^2 = .82$, and intensity × angle of eccentricity interactions, $F(4, 60) = 6.64$, $p < .001$, $\eta_p^2 = .31$. The interaction between task and intensity emerged because the difference in emotion discrimination performance between low and high intensity expressions was greater for angry stimuli than for happy stimuli. Means and standard errors are depicted for this interaction in Table 4.

Table 4
Mean d' values of the Task and Intensity interaction.

	Low		High	
Task	Mean	SE	Mean	SE
Angry/Neutral	1.30	.13	2.48	.18
Happy/Neutral	2.12	.16	2.52	.19

To decompose the interaction between intensity and angle of eccentricity, separate ANOVAs were performed for each intensity condition averaged across task to examine the impact of angle of eccentricity on emotion discrimination performance. Both

ANOVAs conducted on the low expressive intensity trials and the high intensity trials yielded main effects of angle of eccentricity, $F(4, 60) = 43.27$, $p < .001$, $\eta_p^2 = .74$, and $F(4, 60) = 20.46$, $p < .001$, $\eta_p^2 = .58$, respectively. Least significant difference post-hoc tests revealed that, for low intensity expressions, emotion discrimination was best at the central location relative to the peripheral locations (*p*s < .001). Also, performance was better for stimuli presented to locations at -20º, -10º, and +10º than those presented at +20º (*p*s < .001). For high intensity expressions, emotion discrimination was best at the central location, which was not different from the performance at +10º ($p = .058$) but was significantly greater than the performance at the other 3 locations (*p*s ≤ .01). Performance was worse at +20º than at -10º and +10º (*p*s < .001), performance was worse at -20º than at +10º ($p < .001$), and performance at +10º was significantly greater than performance at -10º ($p < .001$), with only minor differences if any between the other peripheral locations. See Figure 5. The interaction between intensity and angle of eccentricity emerged because of a steeper decline in emotion discrimination performance in the right visual field for low intensity stimuli than high.

Note that the findings from these exploratory analyses support Hypothesis 1 and Hypothesis 2. For Hypothesis 1, there was no average difference in emotion discrimination performance when angry and happy stimuli consisted of high intensity expressions, but performance was greater for happy expressions than for angry expressions. For Hypothesis 2, emotion discrimination performance declined as stimuli were presented further into the periphery for both low and high intensity stimuli.

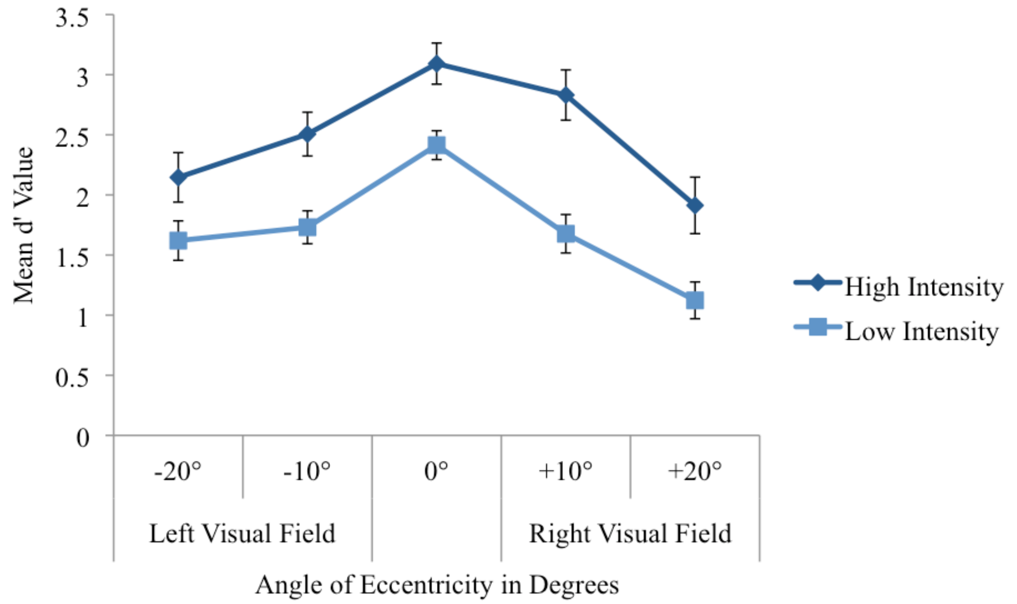

Figure 8. The intensity by angle of eccentricity interaction described above. Note the difference in the rate of decline for the right visual field between the high intensity and low intensity data.

Electrophysiological Data. Peak voltage amplitude was determined for the P1 and N170 components using the same averaging technique described above. Here, however, fewer segments were included in each average as the addition of expressive intensity as an independent variable necessitated the distribution of trials into low and high intensity conditions. At each stimulus location, there were at most 14 high intensity trials for the angry and happy conditions and 34 low intensity trials. Visually-evoked potentials to neutral stimuli were averaged in a manner identical to the prior analysis of electrophysiological data, with peak voltages being averaged across trials within each task. Note that trials were blocked by emotion task, so data from neutral trials here are also associated with the emotion task in which they were observed by participants. Also, for the purpose of these analyses, neutral expressions were included in the expressive intensity variable as a third level (i.e., neutral, low, and high intensity).

P1 Amplitudes. A 3 (Intensity: neutral, low, and high) × 2 (Task: angry/neutral task and happy/neutral task) × 5 (Angle of Eccentricity: -20°, -10°, 0°, +10°, and +20°) × 3 (Hemisphere: left, central, and right) repeated-measures ANOVA was conducted on P1 amplitudes. There was a main effect of intensity, $F(2, 30) = 20.84$, $p < .001$, $\eta_p^2 = .581$, and a main effect of angle of eccentricity, $F(4, 60) = 19.39$, $p < .001$, $\eta_p^2 = .564$. No other significant main effects or interactions were found. Least significant difference post hoc tests demonstrated that high intensity expressions ($M = 3.70$ μV, $SE = 0.32$ μV) elicited a larger amplitude P1 than low intensity ($M = 3.10$ μV, $SE = 0.36$ μV) and neutral ($M = 2.91$ μV, $SE = 0.33$ μV) expressions (*p*s < .001). The impact of angle of eccentricity on P1 amplitude in this analysis is identical to what was reported earlier.

Additional ANOVAs were run on the angry and happy task data separately. For the angry task, a 3 (Intensity: high, low, and neutral) × 2 (Hemisphere: left and right) × 5 (Angle of Eccentricity: -20°, -10°, 0°, 10°, and 20°) repeated-measure ANOVA was run on the P1 amplitudes. There was a main effect of intensity, $F(2, 30) = 17.12$, $p < .001$, $\eta_p^2 = .53$, and a main effect of angle of eccentricity, $F(4, 60) = 19.10$, $p < .001$, $\eta_p^2 = .56$. Least significant difference post-hoc tests demonstrated that the main effect of intensity for the angry task was due to the high intensity faces ($M = 3.81$ μV, $SE = .37$) having more extreme amplitudes than the low intensity ($M = 3.17$ μV, $SE = .40$) or neutral ($M = 3.02$ μV, $SE = .35$) faces, *p*s < .001. There was no difference found between the low intensity and neutral faces. The impact of angle of eccentricity on P1 amplitude in this analysis is again identical to what was reported earlier.

For the happy task, a 3 (Intensity: high, low, and neutral) × 2 (Hemisphere: left and right) × 5 (Angle of Eccentricity: -20°, -10°, 0°, 10°, and 20°) repeated-measure

ANOVA was run on the P1 amplitudes. There was a main effect of intensity, $F(2, 30) = 8.95$, $p < .001$, $\eta_p^2 = .37$, and a main effect of angle of eccentricity, $F(4, 60) = 15.56$, $p < .001$, $\eta_p^2 = .51$. Least significant difference post-hoc tests demonstrated that the main effect of intensity for the happy task was due to the same patterns as for the angry task. High intensity faces ($M = 3.59$ µV, $SE = .31$) had more extreme amplitudes than the low intensity ($M = 3.04$ µV, $SE = .34$) or neutral ($M = 2.86$ µV, $SE = .33$) faces, ps < .007. There was no difference found between the low intensity and neutral faces. The findings for both of these ANOVAs partially support Hypothesis 3. For both the angry and the happy task, the voltage amplitude of the P1 was greater for the high intensity emotional faces than neutral faces, which supports the hypothesis. However, the P1 amplitudes were not greater for low intensity emotional faces relative to neutral faces, contrary to the expectations of the hypothesis.

The impact of angle of eccentricity on P1 amplitude in this analysis is similar to what was reported earlier. Least significant difference post-hoc tests found that amplitudes at the 0° location ($M = 4.96$ µV, $SE = 0.64$ µV) were more extreme than at any other angle of eccentricity, ps <.003. The amplitudes of the P1 to facial images located at -10° ($M = 3.00$ µV, $SE = 0.32$ µV) and +10° ($M = 2.94$ µV, $SE = 0.28$ µV) were not different from one another, nor were the amplitudes of the P1 to facial images located at -20° ($M = 2.27$ µV, $SE = 0.27$ µV) and +20° ($M = 2.62$ µV, $SE = 0.31$ µV). Amplitudes at -10° were more extreme than amplitudes at -20°, $p < .001$. Amplitudes at +10° were also more extreme than amplitudes at -20°, $p < .001$. No other significant differences occurred. Again similar to what was reported earlier, the findings partially support Hypothesis 4. Peak P1 amplitude declined as stimuli were presented further into the periphery, though the decline was not proportionally larger for angry faces than for happy faces. Also as previously found for the P1 amplitudes, the data failed to support Hypothesis 5, as no differences were observed in P1 amplitude as a function of cortical hemisphere.

N170 Amplitudes. A 2 (Task: angry/neutral and happy/neutral) × 3 (Intensity: high, low, and neutral) × 5 (Angle of Eccentricity: -20°, -10°, 0°, 10°, and 20°) × 2 (Hemisphere: left and right) repeated-measures ANOVA was performed on the N170 minimum amplitudes of visually-evoked potential to the onset of facial stimuli. There was a main effect of intensity, $F(2, 30) = 34.74$, $p < .001$, $\eta_p^2 = .70$, and task × intensity, $F(2, 30) = 8.33$, $p < .001$, $\eta_p^2 = .36$, and task × hemisphere interactions, $F(1, 15) = 5.49$, $p = .033$, $\eta_p^2 = .268$. The task by intensity interaction is displayed in Table 5 below. Note that for both tasks, high intensity faces were associated with amplitudes that were more extreme than low intensity faces, which in turn had more extreme amplitudes than neutral faces. The task by hemisphere interaction is displayed in Table 6 below. Note that for both tasks, the right hemisphere had a larger N170 than the left hemisphere, though there appears to be a larger difference for happy faces. Overall, the data do not support Hypothesis 4 as there was no difference in the N170 amplitudes due to the angle of eccentricity at which the faces were displayed. However, the data do partially support Hypothesis 5 as the amplitude of the N170 measured over the right hemisphere was greater than over the left hemisphere, although there was no difference by angle of eccentricity, which had been an expected possibility.

Table 5
Mean µVs of the Task and Intensity interaction.

	High		Low		Neutral	
Task	Mean	SE	Mean	SE	Mean	SE
Angry	-3.83	.57	-2.63	.47	-2.33	.41
Happy	-3.36	.47	-2.87	.38	-2.46	.38

Table 6
Mean µVs of the Task and Hemisphere interaction.

	Left		Right	
Task	Mean	SE	Mean	SE
Angry	-2.72	.40	-3.14	.57
Happy	-2.51	.35	-3.29	.52

In order to decompose the task × intensity interaction, separate ANOVAs were run for the angry/neutral task and the happy/neutral task. For the angry task, a 3 (Intensity: high, low, and neutral) × 2 (Hemisphere: left and right) × 5 (Angle of Eccentricity: -20°, -10°, 0°, 10°, and 20°) repeated-measure ANOVA was run on the N170 amplitudes. There was a main effect of intensity, $F(2, 30) = 30.25$, $p < .001$, $\eta_p^2 = .67$. Least significant difference post-hoc tests demonstrated that the main effect of intensity for the angry task was due to the high intensity faces (*M* = -3.83 µV, *SE* = .57) having more extreme amplitudes than the low intensity (*M* = -2.63 µV, *SE* = .47) or neutral (*M* = -2.33 µV, *SE* = .41) faces, *p*s < .001. There was no difference found between the low intensity and neutral faces. The data partially support Hypothesis 3 because the voltage amplitude of the N170 was greater for the high intensity emotional faces than neutral faces. However, the N170 amplitudes were not greater for low intensity emotional faces relative to neutral faces, contrary to the expectations of the hypothesis.

For the happy task, a 3 (Intensity: high, low, and neutral) × 2 (Hemisphere: left and right) × 5 (Angle of Eccentricity: -20°, -10°, 0°, 10°, and 20°) repeated-measure ANOVA was run on the N170 amplitudes. There was a main effect of intensity, $F(2, 30) = 20.58$, $p < .001$, $\eta_p^2 = .59$. Least significant difference post-hoc tests demonstrated that the main effect of intensity for the happy task was due to the high intensity faces (M = -3.36 µV, SE = .47) having more extreme amplitudes than the low intensity (M = -2.87 µV, SE = .38) faces, $p < .002$, which each had more extreme amplitudes than neutral faces (M = -2.46 µV, SD = .38), ps < .01. These data support Hypothesis 3 in full. The voltage amplitude of the N170 was greater for both types of emotional faces than for the neutral faces.

Overall, it appears that the task × intensity interaction emerged due to the larger amplitude N170 evoked by high intensity angry expressions relative to high intensity happy expressions.

N170 Latencies. As mentioned above, because the latency of the N170 can be delayed when emotional faces are presented in the periphery (Rigoulot et al., 2011), latencies were also analyzed. A 2 (Task: angry/neutral and happy/neutral) × 3 (Intensity: high, low, and neutral) × 5 (Angle of Eccentricity: -20°, -10°, 0°, 10°, and 20°) × 2 (Hemisphere: left and right) repeated-measures ANOVA was performed on the N170 latencies for both angry and happy faces. There were main effects of intensity, $F(2, 30) = 7.61$, $p < .002$, $\eta_p^2 = .34$, and angle of eccentricity, $F(4, 60) = 10.35$, $p < .001$, $\eta_p^2 = .41$, as well as task × intensity, $F(2, 30) = 9.65$, $p < .001$, $\eta_p^2 = .39$, and task × intensity × hemisphere × angle of eccentricity interactions, $F(8, 120) = 2.27$, $p = .027$, $\eta_p^2 = .13$.

Given that there are a small number of possible segments available to interpret differences between the cells of the four-way interaction, it was not explored further.

Least significant difference post-hoc tests demonstrated that the main effect of angle of eccentricity was due to shorter latencies when faces were displayed at 0° (centrally) than at any peripheral location, all *p*s $< .003$. Latencies were also significantly shorter at -10° than at -20°, $p = .019$. No other differences were found. See Figure 6 below for this data presented graphically.

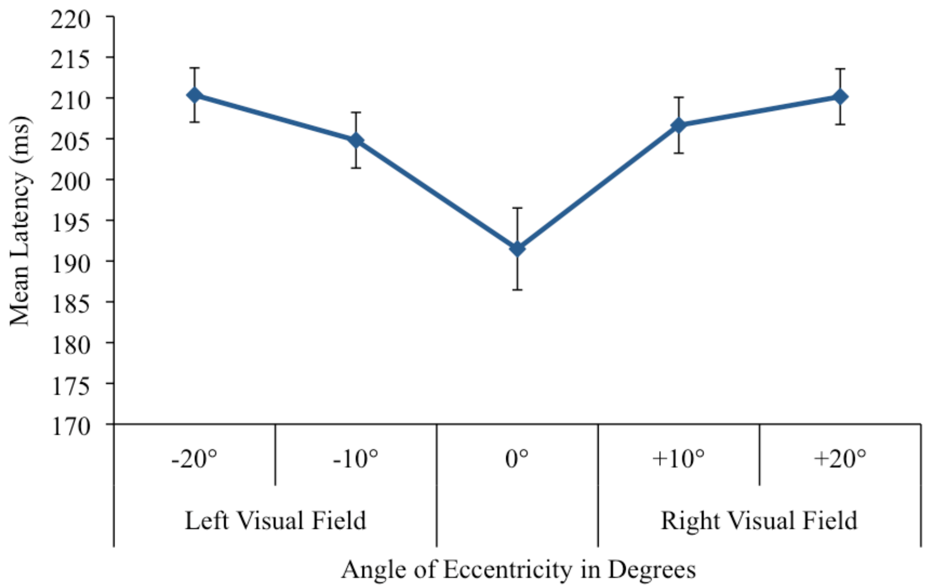

Figure 9. Latencies of the N170 component at each angle of eccentricity.

The task × intensity interaction is displayed in Table 7 below. Note that, for the angry task, high intensity faces appear to have longer latencies, and, for the happy task, there appears to be no difference between intensities.

Table 7
Mean Latencies (ms) of the Task and Intensity interaction.

	High		Low		Neutral	
Task	Mean	SE	Mean	SE	Mean	SE
Angry	212	3	204	3	202	4
Happy	204	3	205	4	201	3

This was confirmed using follow-up ANOVAs examining the impact of Intensity (3: high, low, and neutral) × Hemisphere (2: left and right) × Angle of Eccentricity (5: -20°, -10°, 0°, 10°, and 20°) on the N170 latencies for each task type. For the angry/neutral task, there was a main effect of intensity, $F(2, 30) = 11.77$, $p < .001$, η_p^2=.44. Least significant difference post-hoc tests demonstrated that high intensity faces (*M* = 212 ms, *SE* = 3) had more extreme amplitudes than the low intensity (*M* = 204 ms, *SE* = 3) or neutral (*M* = 202 ms, *SE* = 41) faces, *p*s < .001. There was no difference in latency between the low intensity and neutral faces. For the happy/neutral task, no significant effects emerged.

Discussion

The current study uses behavioral data (i.e., emotion detection d') and neurophysiological data to extend previous research on the detection of emotion in peripherally presented face stimuli. Overall, facial emotion discrimination was best when stimuli were presented foveally, regardless of emotion, and then declined as stimuli were presented further into the periphery. The behavioral data demonstrated that happy faces were easier to discriminate from neutral faces than were angry faces. From an electrophysiological standpoint, the voltage amplitude of the P1 component recorded at occipital electrodes was greater for emotional stimuli (especially intense expressions) than for neutral stimuli. This is consistent with the interpretation that the emotional content of the stimuli may enhance the allocation of attention to peripherally presented faces (Bocanegra & Zeelenberg, 2011; Mohanty & Sussman, 2013; Phelps et al., 2006). Additionally, face processing, indexed by the voltage amplitude of the N170 component recorded at occipito-temporal electrodes (Bentin et al., 1996; Halgren et al., 2000; Maurer et al., 2002; Towler & Eimer, 2015), was enhanced by emotion as well. However, the N170 component was delayed for angry expressions relative to neutral ones, suggesting that perhaps anger is harder to evaluate across targets. Consistent with prior studies, ERP component latencies were delayed when stimuli appeared in the periphery, suggesting that more time is needed for information accrual to take place to register a "face" signal from stimuli communicated from the peripheral regions of the retina to the visual system (Rigoulot et al., 2011).

Behavioral Results

We expected to see that participants would have an easier time detecting happy expressions relative to neutral than they would detecting angry expressions (Hypothesis 1). Although both expressions involve mouth cues, successful detection of anger also involves integrating emotion cues conveyed by the targets' eyes. In all peripheral locations, emotion detection was easier for happy expressions than angry ones. However, at 0°, participants were equally able to detect anger and happiness. Calvo, Fernández-Martín, and Nummenmaa (2014) found that happy faces were easier to detect in peripheral vision than negative emotional faces, and they attributed their findings to the distinctiveness of the smile found on happy faces.

The distinct association between a smile and happiness becomes more important to emotion detection as faces are displayed in peripheral vision. Cones are densely packed in the fovea region of the eye and become less densely packed outside of the fovea, which means that the sensitivity to fine details (like facial features) declines. More specifically, the distance between the cone receptors of the peripheral regions of the retina is wider, necessitating spatially larger stimulus features to facilitate emotion detection in the periphery (Rosenholtz, 2016). The increased size of the emotion cues captured by a broad smile in the mouth region would facilitate maintained emotion detection ability into one's peripheral vision. The changes to the eye region that distinguish anger from neutral emotion are less salient, since the size of the changes in the face are small on the target stimuli, and therefore harder to detect in the periphery. Certainly, less intense expressions of happiness (e.g., mouth closed), would reduce the benefit of the high contrast mouth cues because of the reduction in size of the smile.

Interestingly, when the data were decomposed for exploratory analyses to examine the impact of expressive intensity on emotion detection, performance was better for high intensity expressions than for low intensity expressions. More intense expressions depict emotion cues in a manner that make them more salient to observers. Socially speaking, by more intensely expressing one's emotion, one is trying to communicate as clearly as possible to a nearby partner the degree of impact that the environment (including other people) is having on their comfort or pleasantness. In the current study, increasing expressive intensity (from low to high) had a larger impact on anger detection than it did on happiness detection. Perhaps this was due to visual distinctiveness of the mouth cues produced during a smile, as earlier studies have suggested. Socially speaking, there may be less of a benefit to an observer for ramping up perceptual processing when a stranger expresses increasing levels of happiness than when a stranger expresses increasing levels of anger. Alternatively, perhaps less intensely expressed anger reflects more of a minor annoyance on the part of the actor, whereas more extreme anger is perceived as more of a threat to the observer and is prioritized. Still another possibility is that extreme angry expressions also involve more distinct mouth cues (like happy expressions) that facilitate their detection.

In addition to observing emotion-specific performance differences, we also expected to find that discriminability of emotional faces in general would decline as the stimuli were presented further into the periphery (Hypothesis 2). This prediction stems from the limitations to emotion cue perception emerging from the greater distance between photoreceptors outside of the fovea. The expected reduction in emotion detection was observed, but was also accompanied by a hemifield difference. In both the angry/neutral and happy/neutral tasks, performance peaked at the 0° central presentation and declined at 10° to the left and right. However, though performance further declined for faces presented at 20° in the right visual field, there was no further decline for faces presented at 20° in the left visual field. The difference in discriminability when stimuli are presented to the left instead of the right visual field is intriguing and requires additional explanation. Past research has found that face processing in the brain is lateralized to the right hemisphere (Kanwisher, McDermott, & Chun, 1997; Rossion, Joyce, Cottrell, & Tarr, 2003). This lends itself to an advantage to faces presented in the contralateral visual field, or left visual field. It is likely that the faces presented at 20° in the left visual field benefited from being on the side that side of visual space that received the advantage in processing, explaining the lack of further decline when compared to the faces presented at 20° in the right visual field.

Neurophysiological Results

Although behavioral data inform our understanding of the ability of emotion cues to facilitate decisions made in emotion discrimination tasks, the neurophysiological indicators evoked by the visual presentation of the stimuli make it possible to more directly examine the impact of emotion cues on the visual system. We expected to see that the voltage amplitudes of the P1 and N170 components would be greater in response to emotional faces than neutral faces (Hypothesis 3), which previous research has attributed to greater attentional capture by the emotional face (Chambers, 2015; Rellecke et al., 2012). Initially, the data suggested that emotion only marginally impacted N170 amplitude; however, further exploration revealed that *intense* emotion elicited larger voltage amplitude for both P1 and N170 components. The P1 component was more enhanced in general to more intense emotional faces relative to low intensity expressions and neutral faces. The N170 was likewise enhanced for more intense emotional faces, though even more enhanced for the high intensity angry faces in comparison to the high intensity happy faces. Consistent with the aforementioned behavioral findings, the faces with more salient emotion cues were easier to detect and elicited greater activation from the visual system.

Given that emotion cues are more challenging to detect in the periphery, we also expected emotion cues to benefit peak voltage amplitudes of the P1 and N170 when faces were presented toward the center of the display (Hypothesis 4). An attenuation for peak P1 voltage amplitude was observed in both the happy and angry tasks as the facial stimuli were presented further into the periphery. Conversely, a similar attenuation of the peak N170 voltage amplitude was not observed. The lack of an attenuation of the N170 in the periphery is consistent with Rigoulot and colleagues (2011), who found that emotional enhancements to N170 amplitude evoked by fearful facial expressions were maintained out to 30°. As for the P1 attenuation, previous studies have found that the amplitude of the P1 component can be enhanced with attention to stimuli and reduced when stimuli are displayed with attention focused elsewhere (Wijers & Banes, 2012). It could be that that the instructions for participants to focus on the central fixation target and be certain to not move their eyes drew additional attention to the fixation target at the expense of attending to the periphery or that these instructions limited the participants' ability to direct their attention over such a wide visual angle.

Furthermore, we expected to find that the peak amplitudes of the P1 and N170 would be greater when measured over the right hemisphere than the left for emotional faces (Hypothesis 5). This was found for the N170 component; the peak voltage amplitude of the N170 was greater for the right hemisphere than the left, consistent with previous research (Towler & Eimer, 2015). This enhancement for emotional faces may be in part explained by the connections and communication between the fusiform face area in the right hemisphere and the amygdala (Vuilleumier & Pourtois, 2007). There was also a greater difference between hemispheres for happy faces than for angry faces. Further research may be necessary to determine the reasons why.

In addition to examining peak voltage amplitude, the current study also examined the latency of the N170 peaks in light of past research which suggests that a peripheral presentation of facial stimuli leads to a delay in face processing (Batty & Taylor, 2003; Rigoulot et al., 2011; Rigoulot et al., 2012). Delays in the N170 component were observed for angry and for happy expressions and for peripherally-presented faces as opposed to centrally-presented faces, with a longer delay for faces presented farther in the periphery. There was an additional delay for angry faces, which is consistent with the finding by Batty and Taylor (2003) that negative emotional faces have longer latencies than positive emotional faces. Batty and Taylor (2003) also found that their high intensity angry faces had the longest latency compared to every other emotion/intensity pairing used, which is what was found in the current study as well. A possible reason for the more extreme reaction overall to the high intensity emotional faces could be that the more exaggerated expressions of high intensity faces appear to deviate from the usual layout of facial features and require more time in order to perceive them as faces than lower intensity expressions.

Limitations

This study, as with any, had some limitations. Firstly, the sample size remaining after participants had to be dropped was relatively small ($n = 16$). This sample size is not unusual for an ERP experiment due to the time it takes to run the experiment for each participant and the high number of segments each participant provides. However, this sample size makes it incredibly difficult to interpret multi-factorial interactions (e.g., four-way interaction) because of the limited number of segments (or trials) per cell of the interaction. If more people had been sampled or more trials included, higher interactions may be more reliable. Secondly, the intensity manipulation was created by using open and closed mouth faces, which creates the possibility of confounding intensity and mouth status as factors. Future research should manipulate high and low intensity cue expressiveness separately from open and closed mouth faces to examine the independent contributions of each factor. Finally, there was a limit within the experimental design for how much of the epoch could be analyzed. After stimulus offset, the response screen was displayed with choice labels in order to lessen the chance of participants forgetting which button corresponded to which response. This means that the ERP waveforms cannot be interpreted from that point on except through difference comparisons, as deflections in the ERP from that point on could be due to either the stimulus or to the response labels themselves. However, because all comparisons in the reported analyses were made between conditions and all conditions were presented identically, it is likely that, if these response labels had any effect, it would be equally distributed across all conditions and not unduly influence one condition over another.

Despite these limitations, the current study extends prior research in a number of ways. Many other experiments had looked at stimuli presented up to a 10° angle of eccentricity (Calvo et al., 2010; Calvo & Beltrán, 2013; Calvo, Fernández-Martín, & Nummenmaa, 2014; Tamamiya & Hiraki, 2013; Wijers & Banis, 2012). The current study presented stimuli at 10° and 20°. This allowed us to examine changes in emotion perception farther into the peripheral visual field. Furthermore, the current study separated the discrete emotions of interest into separate tasks. Previous research has frequently combined multiple emotions in the same block for ease of presentation and inadvertently created a more complex emotion discrimination task (Calvo & Beltrán, 2013; Calvo, Beltrán, & Fernández-Martín, 2014). By separating them into distinct blocks, however, the current study lessens the likelihood of one emotion interfering with the processing of the other emotion. The analyses therefore are more distinctly representative of the participants' response to the specific emotion. A final contribution of this study is the measurement of behavioral and neurophysiological responses to the same event. Many previous emotion perceptions studies have either used passive viewing procedures during the gathering of ERP data or only examined behavioral results for emotion discrimination without an ERP component (Bayle et al., 2011; Wijers & Banis, 2012).

Summary

The current study examined behavioral and neurophysiological indicators of emotional face perception in peripheral vision. Emotion cues depicted on facial stimuli, especially when expressed intensely, influenced how easy it was to detect discrete emotions in peripheral vision. Happy faces were easier to detect in the periphery than were angry faces. However, increased expressive intensity facilitated a larger gain in emotion detection for angry expressions than for happy ones. This was observed both in the behavioral d’ measure as well as in the electrophysiological P1 and N170 amplitudes. Because most stimuli that humans see are first processed in peripheral vision (Strasburger et al., 2011), it would be advantageous for intense emotional expressions to capture attention and to be easier to detect. Human safety and more nuanced social interactions should be supported by the further processing of affective information emerging in one’s peripheral field of view.

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Appendix A

The Center for Epidemiological Studies Depression Scale (CES-D)

Feelings Scale

Instructions: In this booklet, there are statements about the way that most people feel at one time or another. There is no such thing as a "right" or "wrong" answer because all people are different. All you have to do is answer the statements according to how you have felt during the past week. Don't answer according to how you USUALLY feel, but rather how you have felt DURING THE PAST WEEK. Each statement is followed by four choices. ***Circle*** the letter corresponding to your choice. Mark ONLY ONE letter for each statement. For example:

During the past week, I was happy.

a. Rarely or none of the time (less than one day)
b. Some or a little of the time (1 - 2 days)
c. Occasionally or a moderate amount of time (3 - 4 days)
d. Most or all of the time (5 - 7 days)

In the example, you could, of course, choose any ONE of the answers. If you felt really happy, you would circle "d". If you felt very unhappy, you would circle "a". The "b" and "c" answers give you middle choices. Keep these following points in mind.

1. Don't spend too much time thinking about your answer. Give the 1st natural answer that comes to you.

2. Do your best to answer EVERY question, even if it doesn't seem to apply to you very well.

3. Answer as honestly as you can. Please do not mark something because it seems like "the right thing to say".

---

1. During the past week, I was bothered by things that don't usually bother me.

a. Rarely or none of the time (less than one day)
b. Some or a little of the time (1 - 2 days)
c. Occasionally or a moderate amount of time (3 - 4 days)
d. Most or all of the time (5 - 7 days)

2. During the past week, I did not feel like eating. My appetite was poor.

a. Rarely or none of the time (less than one day)
b. Some or a little of the time (1 - 2 days)
c. Occasionally or a moderate amount of time (3 - 4 days)
d. Most or all of the time (5 - 7 days)

3. During the past week, I felt that I could not shake off the blues even with help from my family or friends.

a. Rarely or none of the time (less than one day)
b. Some or a little of the time (1 - 2 days)
c. Occasionally or a moderate amount of time (3 - 4 days)
d. Most or all of the time (5 - 7 days)

4. During the past week, I felt that I was just as good as other people.

a. Rarely or none of the time (less than one day)
b. Some or a little of the time (1 - 2 days)
c. Occasionally or a moderate amount of time (3 - 4 days)
d. Most or all of the time (5 - 7 days)

To continue, please turn to page 2 1

5. During the past week, I had trouble keeping my mind on what I was doing.

a. Rarely or none of the time (less than one day)
b. Some or a little of the time (1 - 2 days)
c. Occasionally or a moderate amount of time (3 - 4 days)
d. Most or all of the time (5 - 7 days)

6. During the past week, I felt depressed.

a. Rarely or none of the time (less than one day)
b. Some or a little of the time (1 - 2 days)
c. Occasionally or a moderate amount of time (3 - 4 days)
d. Most or all of the time (5 - 7 days)

7. During the past week, I felt that everything I did was an effort.

a. Rarely or none of the time (less than one day)
b. Some or a little of the time (1 - 2 days)
c. Occasionally or a moderate amount of time (3 - 4 days)
d. Most or all of the time (5 - 7 days)

8. During the past week, I felt hopeful about the future.

a. Rarely or none of the time (less than one day)
b. Some or a little of the time (1 - 2 days)
c. Occasionally or a moderate amount of time (3 - 4 days)
d. Most or all of the time (5 - 7 days)

9. During the past week, I thought my life had been a failure.

a. Rarely or none of the time (less than one day)
b. Some or a little of the time (1 - 2 days)
c. Occasionally or a moderate amount of time (3 - 4 days)
d. Most or all of the time (5 - 7 days)

10. During the past week, I felt fearful.

a. Rarely or none of the time (less than one day)
b. Some or a little of the time (1 - 2 days)
c. Occasionally or a moderate amount of time (3 - 4 days)
d. Most or all of the time (5 - 7 days)

11. During the past week, my sleep was restless.

a. Rarely or none of the time (less than one day)
b. Some or a little of the time (1 - 2 days)
c. Occasionally or a moderate amount of time (3 - 4 days)
d. Most or all of the time (5 - 7 days)

12. During the past week, I was happy.

a. Rarely or none of the time (less than one day)
b. Some or a little of the time (1 - 2 days)
c. Occasionally or a moderate amount of time (3 - 4 days)
d. Most or all of the time (5 - 7 days)

To continue, please turn to page 3

13. During the past week, I talked less than usual.

a. Rarely or none of the time (less than one day)
b. Some or a little of the time (1 - 2 days)
c. Occasionally or a moderate amount of time (3 - 4 days)
d. Most or all of the time (5 - 7 days)

14. During the past week, I felt lonely.

a. Rarely or none of the time (less than one day)
b. Some or a little of the time (1 - 2 days)
c. Occasionally or a moderate amount of time (3 - 4 days)
d. Most or all of the time (5 - 7 days)

15. During the past week, people were unfriendly.

a. Rarely or none of the time (less than one day)
b. Some or a little of the time (1 - 2 days)
c. Occasionally or a moderate amount of time (3 - 4 days)
d. Most or all of the time (5 - 7 days)

16. During the past week, I enjoyed life.

a. Rarely or none of the time (less than one day)
b. Some or a little of the time (1 - 2 days)
c. Occasionally or a moderate amount of time (3 - 4 days)
d. Most or all of the time (5 - 7 days)

17. During the past week, I had crying spells.

a. Rarely or none of the time (less than one day)
b. Some or a little of the time (1 - 2 days)
c. Occasionally or a moderate amount of time (3 - 4 days)
d. Most or all of the time (5 - 7 days)

18. During the past week, I felt sad.

a. Rarely or none of the time (less than one day)
b. Some or a little of the time (1 - 2 days)
c. Occasionally or a moderate amount of time (3 - 4 days)
d. Most or all of the time (5 - 7 days)

19. During the past week, I felt that people dislike me.

a. Rarely or none of the time (less than one day)
b. Some or a little of the time (1 - 2 days)
c. Occasionally or a moderate amount of time (3 - 4 days)
d. Most or all of the time (5 - 7 days)

20. During the past week, I could not get "going".

a. Rarely or none of the time (less than one day)
b. Some or a little of the time (1 - 2 days)
c. Occasionally or a moderate amount of time (3 - 4 days)
d. Most or all of the time (5 - 7 days)

Appendix B

Generalized Anxiety Disorder Scale (GAD-7)

GAD-7

Over the last 2 weeks, how often have you been bothered by the following problems? *(Use "✔" to indicate your answer)*	**Not at all**	**Several days**	**More than half the days**	**Nearly every day**
1. Feeling nervous, anxious or on edge	0	1	2	3
2. Not being able to stop or control worrying	0	1	2	3
3. Worrying too much about different things	0	1	2	3
4. Trouble relaxing	0	1	2	3
5. Being so restless that it is hard to sit still	0	1	2	3
6. Becoming easily annoyed or irritable	0	1	2	3
7. Feeling afraid as if something awful might happen	0	1	2	3

(For office coding: Total Score T____ = ____ + ____ + ____)

Appendix C

Neuropsychological Screening

Neuropsychological Screening

Date: ____________ Experimenter Initials: ____________ Study: _________

Participant ID #: _______ Handedness Score: _______ Gender: _________ Age: ____

1. Do you have a history of learning problems? ____Yes ____No
2. Have you ever been examined by a neurologist or neuropsychologist? ___Yes ___No
3. Do you have a history of a central nervous system disease ___Yes ___No
4. Do you have a history of high fevers? ____Yes ____No
5. Do you have a history of seizures? ____Yes ____No
6. Do you have a history of balance problems? ____Yes ____No
7. Do you have a history of vertigo or dizziness lasting longer than one hour? ____Yes ____No
8. Have you ever been diagnosed with an inner ear balance problem? ____Yes ____No
9. Have you ever lost consciousness? ____Yes ____No
10. Have you ever had dizziness that lead to nausea or disorientation?____Yes ____No
11. Do you have persistent headaches? ____Yes ____No
12. Have you experienced an event that lead to brain trauma? ____Yes ____No
13. If you said yes to any of the above, please provide a brief explanation here:

14. Do you wear corrective lenses? ____Yes ____No
15. Please list all medications (include vitamins and herbal supplements) you are currently taking. Indicate the name, dosage, and frequency.

Appendix D

Brief Edinburgh Handedness Inventory

Brief Edinburgh Handedness Inventory

Participant ID#: ____________

Have you ever had any tendency to left-handedness? YES NO

Please indicate your preferences in the use of hands in the following activities by putting + in the appropriate column. Where the preference is so strong that you would never try to use the other hand unless absolutely forced to, put ++. If in any case you are really indifferent, put + in both columns.

Some of the activities require both hands. In these cases, the part of the task or object, for which hand-preferences is wanted is indicated in brackets.

Please try to answer all the questions, and only leave a blank if you have no experience at all with the object or task.

	Left	Right
1. Writing	______	______
2. Drawing	______	______
3. Throwing	______	______
4. Scissors	______	______
5. Toothbrush	______	______
6. Knife (without fork)	______	______
7. Spoon	______	______
8. Broom (upper hand)	______	______
9. Striking Match (match)	______	______
10. Opening Box	______	______
Total	______	______

Appendix E

The Behavioral Inhibition and Activation Scales (BIS/BAS)

BIS/BAS

Instructions: Each item of this questionnaire is a statement that a person may either agree with or disagree with. For each item, indicate how much you agree or disagree with what the item says. Please respond to all the items; do not leave any blank. Choose only one response to each statement. Please be as accurate and honest as you can be. Respond to each item as if it were the only item. That is, don't worry about being "consistent" in your responses. Choose from the following four response options:

1 = very true for me
2 = somewhat true for me
3 = somewhat false for me
4 = very false for me

_____ 1. A person's family is the most important thing in life.

_____ 2. Even if something bad is about to happen to me, I rarely experience fear or nervousness.

_____ 3. I go out of my way to get things I want.

_____ 4. When I'm doing well at something I love to keep at it.

_____ 5. I'm always willing to try something new if I think it will be fun.

_____ 6. How I dress is important to me.

_____ 7. When I get something I want, I feel excited and energized.

_____ 8. Criticism or scolding hurts me quite a bit.

_____ 9. When I want something I usually go all-out to get it.

_____ 10. I will often do things for no other reason than that they might be fun.

_____ 11. It's hard for me to find the time to do things such as get a haircut.

_____ 12. If I see a chance to get something I want I move on it right away.

_____ 13. I feel pretty worried or upset when I think or know somebody is angry at me.

_____ 14. When I see an opportunity for something I like I get excited right away.

_____ 15. I often act on the spur of the moment.

_____ 16. If I think something unpleasant is going to happen I usually get pretty "worked up."

_____ 17. I often wonder why people act the way they do.

_____ 18. When good things happen to me, it affects me strongly.

_____ 19. I feel worried when I think I have done poorly at something important.

_____ 20. I crave excitement and new sensations.

_____ 21. When I go after something I use a "no holds barred" approach.

_____ 22. I have very few fears compared to my friends.

_____ 23. It would excite me to win a contest.

_____ 24. I worry about making mistakes.

Appendix F

Lab Demographics Questionnaire

Instructions: The items in this questionnaire ask you for personal information that we can use to get a sense for how similar our group of volunteers is to those who participate in research at other institutions in the United States. All information that we collect from individuals will not be linked back to their identities. However, if you are uncomfortable providing a response for any of the following items, please do not respond to them. For the remaining items, please *fill in the blank spaces* or *circle the response* which best describes you.

1. **Please indicate your gender:** 1. Female 2. Male

2. **Please indicate your marital status:**
   1. Single
   2. Married
   3. Domestic Partnership
   4. Divorced
   5. Widowed
   6. Other (specify) ____________________

3. **Please indicate how many children you have raised or are currently raising.** _____

4. **Date of birth:** _____/_____/_____ **and current age:** ___________ years

5. **Do you consider yourself to be Hispanic or Latino?** 1. YES 2. NO

6. **Please indicate your racial background:**
   1. American Indian/ Alaska Native
   2. Asian
   3. Native Hawaiian or Other Pacific Islander
   4. Black or African American
   5. Caucasian
   6. More than one race (specify) __________________________
   7. Other (specify) ____________________________________

6. **Is English your native language?** 1. Yes 2. No

7. **Please indicate your religious faith:**
   1. Christian (Protestant or Catholic)
   2. Jewish
   3. Hindu
   4. Muslim
   5. Buddhist
   6. None (e.g., atheist)
   7. Other (specify) ________________________

8. **Are you a student?** 1. Yes - full time 2. Yes - part time 3. No

9. **If you are a student, please indicate your academic major:**
   1. Arts (specify) __________________________
   2. Business (specify) __________________________
   3. Engineering (specify) __________________________
   4. Humanities (specify) __________________________
   5. Science (specify) __________________________
   6. Health (specify) __________________________
   7. Education (specify) __________________________
   8. Other (specify) __________________________

To continue, please turn to the other side of this page

10. What is your highest level of formal education (circle the highest level completed):

A. Less than 12 years (How many of years completed? _________ years)
B. GED (Age when you completed your GED: _______)
C. High school diploma
D. Technical/ Vocational/ Trade school diploma or certificate
E. College Freshman
F. College Sophomore
G. College Junior
H. Associate's Degree
I. Bachelor's degree
J. Master's degree
K. J.D., M.D., or Ph.D.

11. Are you presently employed: 1. Yes - full time 2. Yes - part time 3. No

12. Are you presently retired? 1. Yes 2. No

13. If you are currently or have recently been employed, what field is your job in?

____

14. If you are currently or have recently been employed, please describe the duties of your job?

____

____

15. In the past 5 years, have you engaged in volunteer activities to assist or instruct young adults (i.e., individuals aged 18-30)? 1. Yes 2. No

16. To what extent do you interact with young adults throughout the course of a typical week (including time spent at work, in classes, and/or during volunteer or extracurricular activities)?

1. Rarely or none of the time (less than one day)
2. Some or a little of the time (1 - 2 days)
3. Occasionally or a moderate amount of time (3 - 4 days)
4. Most or all of the time (5 - 7 days)

17. How would you rate your overall health at the present time? (please circle one rating)
1. Poor 2. Fair 3. Good 4. Very Good 5. Excellent

18. How much do health problems stand in your way of doing things that you want to do? (please circle one rating) 1. Not at all 2. A little 3. Moderately 4. Quite a bit 5. A great deal

19. Are you presently seeking psychological or psychiatric consultation and/or receiving therapy?
1. Yes 2. No

If yes…
a. Are you currently being treated for depression? 1. Yes 2. No
b. Are you currently being treated for excessive anxiety or nervousness? 1. Yes 2. No

20. Do you currently have any noticeable difficulty with vision for which correction, such as eyeglasses, has NOT been made? 1. Yes 2. No

29. Do you currently have any noticeable difficulty with hearing for which a correction, such as a hearing aide, has NOT been made? 1. Yes 2. No

30. Do you currently have any difficulty with writing? 1. Yes 2. No

Appendix G

IRB Stamped Consent Form

PARTICIPANT INFORMED CONSENT DOCUMENT

Project Title: Peripheral Emotional Expressions and Electroencephalography

Investigators: Dr. Andrew Mienaltowski and Hayley M. Lambert, Department of Psychological Sciences, Western Kentucky University, (270) 745-2353

You are being asked to participate in a project conducted through Western Kentucky University. The University requires that you give your signed agreement to participate in this project.

You must be 18 years old or older to participate in this research study.

The investigator will explain to you in detail the purpose of the project, the procedures to be used, and the potential benefits and possible risks of participation. You may ask any questions you have to help you understand the project. A basic explanation of the project is written below. Please read this explanation and discuss with the researcher any questions you may have.

If you then decide to participate in the project, please sign this form in the presence of the person who explained the project to you. You should be given a copy of this form to keep.

A. Nature and Purpose of the Project:

This project is examining how people detect emotions on photos of faces presented at various angles of eccentricity from a central location on a computer screen, including voltage changes along the scalp that occur when the face images emerge on the display.

B. Explanation of Procedures:

The purpose of this research is to evaluate how quickly and accurately observers can make judgments on faces that appear in their peripheral vision. During the emotion detection tasks, you will be asked to indicate whether a face displayed in the periphery has a neutral expression or an emotional expression. The distance from center will vary between trials. Participants in the study are also asked to complete a short series of personality tests. The purpose of these tests is to determine if individual differences in your ability to detect the emotion are related to social or motivational differences between participants. Any connection that exists likely occurs outside of our awareness and may not be purposefully controlled. Your head will be measured at the beginning of the session to determine the correct size EEG (electroencephalography) sensor net to apply for the experiment. A trained research staff member will then fit you with a sensor net. The net will measure scalp EEG – naturally occurring changes in electrical signal related to brain activity as you examine stimuli on the computer display. Before the net is placed on your head, it will be immersed in a non-toxic, hypoallergenic electrolyte solution, and small sponges within each of the electrodes will soak up the solution. These EEG measurements will help to characterize how you think about emotions that you perceive in the facial expressions of others.

C. Discomforts and Risks of Participation:

There are no known risks associated with participation in these experiments. However, should you become tired, you are free to quit at any time. There are opportunities to take breaks between tasks in the experiment. Please do not hesitate to ask the experimenter for time for a break should you need one. Also, you will be wearing a net that is soaked in potassium chloride, baby shampoo, and water solution. This means that your hair may be damp after the experiment. You are welcome to dry off or blow dry your hair in the lab.

WKU IRB# 16-306
Approval - 2/4/2016
End Date - 1/31/2017
Expedited
Original - 2/4/2016

INSTITUTIONAL REVIEW BOARD
WKU
APPROVED

D. Benefits of Participation:

Your participation will help to further our efforts to understand how visual perception of the emotions displayed by photos of faces are impacted by the location of those faces within our visual field. Understanding how the expressions of others influence our vision is important to understanding the ways that we think about others during our social experiences. Once the experiment is complete, we would be happy to share the results with you.

E. Confidentiality of Your Responses:

During this study, you will be asked for some personal information (name, age, gender, etc.). This information will be confidential and will only be used by the experimenter. The data that is collected about you will be kept private. To protect your privacy, your records will be kept under a code number rather than by name. Your records will be kept in locked files and only study staff will be allowed to look at them. We are only interested in group information. The reporting of the experimental results will only contain group mean results and will contain NO personal information about individual participants, including performance during the experiment. Your name and any other fact that might point to you will not appear when results of this study are presented or published. To make sure that this research is being carried out in the proper way, the Western Kentucky University Human Subjects Institutional Review Board will review study records.

F. Compensation for Participation:

You will receive a $10 gift card. You will also receive one Study Board credit for every fifteen minutes of participation, up to 8 credits.

G. In Case of Harm or Injury:

Reports of injury or reaction should be made to Dr. Andrew Mienaltowski, by phone at (270) 745-2353 or by e-mail andrew.mienaltowski@wku.edu. Neither Western Kentucky University nor the principal investigator have made provision for payment of costs associated with any injury resulting from taking part in this study.

I. Refusal/Withdrawal:

Refusal to participate in this study will have no effect on any future services you may be entitled to from the University. Anyone who agrees to participate in this study is free to withdraw from the study at any time with no penalty.

You understand also that it is not possible to identify all potential risks in an experimental procedure, and you believe that reasonable safeguards have been taken to minimize both the known and potential but unknown risks.

_______________________________________ ______________

Signature of Participant Date

_______________________________________ ______________

Witness Date

THE DATED APPROVAL ON THIS CONSENT FORM INDICATES THAT
THIS PROJECT HAS BEEN REVIEWED AND APPROVED BY
THE WESTERN KENTUCKY UNIVERSITY INSTITUTIONAL REVIEW BOARD
Paul Mooney, Human Protections Administrator
TELEPHONE: (270) 745-2129

WKU IRB# 16-306
Approval - 2/4/2016
End Date - 1/31/2017
Expedited
Original - 2/4/2016

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