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An Electrophysiological Study on Sex-Related Differences in Emotion Perception

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Abstract

The purpose of this research project was examine the following question: Do men and women respond differently, on a neurophysiological level, to stimuli that elicit an emotional valence? Participants completed an emotional expression face identification task in which participants made speeded responses to angry, happy, and neutral emotional faces. Behavioral and event-related potential (ERP) methods were utilized to examine emotion processing differences between females and males and whether those differences were associated with emotional arousal or emotion regulation differences. Results indicated that females and males did not differ in accuracy or response time. Furthermore, there were no observable differences in the P1 ERP waveform reflecting emotional arousal or the P3 waveform reflecting emotional regulation between female and male adults. Therefore, we did not find evidence for differential emotional arousal and emotion regulation processes between females and males.

Background/Context

Past individual difference research on emotional identification has examined attentional capacity (Shaw et al. 2011), age differences (Pollock et al. 2012; Houston et al. in 2018a), medical conditions (Houston et al., 2018b), and personality abnormalities (Levant et al. 2014; Jardin et al., in preparation). However, limited research exists in regard to how these mechanisms differ based on gender.

In the existing research on gender differences in emotional processing, Gard & Kring (2007) found that men and women do differ in emotional expressivity, and that this difference may be due to gender differences in approach-avoidance motivational systems, which supports the idea that differences in emotional expressivity is not merely due to social constructs of gender. This study was limited in that it used self-report data, as well as electromyographic (EMG) recordings. These measures lack the ability to observe differences in the processing of emotions that exist at a cognitive level.

The electroencephalogram (EEG) is an effective way to study emotional arousal and regulation because it has the ability to measure, with high temporal resolution, the brain's response to a stimulus. When time-locked to trial events, averaged electroencephalography activity is referred to as event-related potentials (ERPs). Two ERP components are the P1 and P3 waveforms. The P1 waveform, which is typically measured 70-170 seconds post-stimulus onset, is associated with preconscious processes, whereas the later P3 waveform (300-600 ms) is associated with processes that occur with effortful control (Luck, 2014; Krolak-Salmon et al., 2001; Polich, 1996; Vogel, Luck, & Shapiro, 1998).

Lithari et al. (2010) found that unpleasant and high arousing stimuli evoke greater ERP amplitudes in women relative to men. However, this study is limited in several ways. First, it reports peak ERP effects, rather than the standard area-under-the-curve approach recommended by professionals in the ERP field (Luck, 2005; Woodman, 2010). Second, this study does not test for specific emotions to represent emotional valence (for example, angry, happy, and neutral), which is inconsistent with much of the present research. Instead, the visual stimuli of this paradigm consisted of images selected from the International Affective Picture System (IAPS) collection based on their emotional content, defined in terms of their ratings of pleasure and arousal (pleasant and high arousing, pleasant and low-arousing, unpleasant and high-arousing, and unpleasant and low-arousing). Third, this study may lack a clean ERP due to the low number of stimuli per cell (they used 40 stimuli per cell).

In the proposed study, I predict that men and women will respond differently to stimuli that illicit an emotional valence. Specifically, I hypothesize that the presentation of emotionally expressive faces would be more salient for women than for men, which may be due to the fact that women have a heightened threat perception system relative to men. If this is true, we will observe relatively larger P1 and P3 amplitudes for angry vs. happy or neutral faces in women relative to men. In addition, men, in general, will show lower-amplitude ERP responses than women.

This information will allow us to further understand how humans experience and respond to emotional experiences in the world. It may also have implications on our understanding of certain pathologies related to emotion perception.

Methodology

I will use the methodology described by Houston et al. (2018a) as the basis for my research. However, rather than testing younger and older adults, I will be looking at men and women. In addition, I will be using the Grael V2 amplifier instead of the amplifier used by Houston et al. (2018a; 2018b).

Participants: I recruited 16 men and 17 women from the University of Akron. All participants had normal corrected vision. Examination of participant fatigue over the 70 minute experiment was explored in the behavioral and EEG data in order to monitor effects of fatigue (ex: more frequent eye blinks).

Apparatus, stimuli, and procedure: For the emotion perception task, stimuli were presented centrally on a 23-inch Dell LCD monitor appending approximately 9.53° (height) by 6.75° (width). Each trial consisted of a single stimulus presentation consisting of a color image of a face presented against a black background. Thirty images, taken from the NimStim database (Tottenham et al., 2009), were used that comprise three emotional expressions (happy, angry, and neutral) from 10 different actors (5 male, 5 female). The actors in these images are a mixture of African-, Asian-, European-, and Latino-American descent. The emotional expressions in the NimStim database are standardized so that angry and happy faces are extreme versions of these emotional expressions. Each face was presented 40 times, including 36 practice trials. Each trial started with the presentation of a white fixation cross on a black background that persisted for 800 ms. After a 100, 300, or 900 ms onset delay, randomized within blocks, the stimuli appeared and remained until a response was collected. Participants will be asked to determine the emotional expression of the target face by pressing the keys “V”, “B”, and “N” for angry, happy,

and neutral emotions, respectively, as quickly and accurately as possible. Participants performed one practice block of 36 trials, followed by 16 experimental blocks of 72 trials each for a total of 1,152 experimental trials. Mean reaction time and accuracy feedback were provided after each block, and participants were encouraged to take breaks after completing individual blocks.

*EEG recording and analyses**:*** Electrophysiological data was recorded using a 32 channel Neuroscan EEG using Quik-caps with silver chloride (AgCl) electrodes in reference to the average of the left and right mastoid. In order to control for ocular artifacts, a horizontal electrooculogram (HEOG) was recorded from the outer canthi of both eyes and a vertical electrooculogram (VEOG) was recorded above and below the midpoint of the left eye. Impedance was kept below 5kΩ. The EEG, HEOG, and VEOG were amplified using a Grael V2 amplifier and digitized at 500 Hz. All waveforms were analyzed using the ERPLab 6 and EEGLab 13 toolboxes in Matlab 2016b (Delorme & Makeig, 2004; Lopez-Calderon & Luck, 2014; Mathworks, Natick, MA). A half-amplitude high pass filter of 0.1 Hz with a 12 decibel/octave roll-off was applied to the data prior to artifact detection. Independent components were calculated from the continuous data using the runica algorithm in EEGLab. Highly probable artifact components in the continuous data files were identified and rejected based upon spatial and spectral waveform characteristics with the assistance of the MARA toolbox plugin (Winkler, Haufe, & Tangermann, 2011). Subsequent to the component rejection, 3000 ms epochs were established and time-locked to 1000 ms pre-stimulus onset. A 200 ms pre-stimulus onset was used as a baseline for artifact rejections in EEGLab. The P1 and P3 ERP components were computed utilizing the ERPLab toolbox. For the analysis, the P1 waveform was operationalized as the average positive amplitude in microvolts (μV) at Oz and Pz in the

window of 100-200 ms after stimulus onset relative to the 200 ms pre-stimulus to stimulus onset baseline. The 100-200 ms window was selected to best account for younger and older adult P1 waveform characteristics due to the older adults' later P1 latencies. The P3 ERP measurement was established by taking the average positive amplitude (μV) at Cz and Pz in the window of 300 to 600 ms after the stimulus onset relative to the -200 ms to stimulus onset baseline.

Results

Prior to engaging in the emotion perception task, participants completed a measure of processing speed, the digit symbol coding task. There were no gender differences in the digit symbol coding task, $t(31) = 0.358$, $p = 0.723$.

Behavioral analysis for the emotion perception task were conducted using a two factor ANOVA in which gender (female vs. male) was treated as a between-groups factor and emotional expression (angry vs. happy vs. neutral) served as a within-subjects factor. When relevant, Greenhouse-Geisser corrections were utilized for breaks in compound symmetry and false discovery rate corrections were utilized for all simple effects as described by Benjamin & Yekutieli (2001).

Table 1 provides mean values for the emotional expressions by gender and emotional expression. Females and males did not differ in accuracy $F(1,31) = 1.18$, $p = 0.286$. Across genders, neutral emotional expressions were identified more accurately compared to angry or happy emotional expressions, with no differences between the latter, $F(2,62) = 4.18$, $p = 0.020$. Similarly, for response time, there was no gender effect, $F(1,31) = 0.21$, $p = 0.653$. Both groups identified happy emotional expressions faster than angry emotional expressions, with no significant differences involving neutral expressions, $F(2,62) = 5.97$, $p = 0.004$. The gender by emotion interactions were not significant for accuracy or response time (p's > 0.295).

Table 1.
Mean ERP and behavioral values as a function of emotional expression and gender.

		Females			Males		
Measure	Channel	Angry	Happy	Neutral	Angry	Happy	Neutral
P1	Pz	1.947	1.942	1.735	4.023	3.981	3.582
	Oz	3.624	3.465	3.713	4.127	3.796	3.713
P3	Cz	3.567	3.323	3.173	5.724	5.374	5.033
	Pz	6.232	6.041	6.118	10.455	9.925	9.821
Percentage correct		0.938	0.959	0.967	0.962	0.961	0.975
Response time (ms)		900	847	896	874	838	846

ERP analysis was conducted separately for P1 and P3 components using three factor ANOVAs in which gender (female vs. male) was treated as between-groups effect and emotional expression (angry vs. happy vs. neutral) and channel (Pz and Oz for P1, Cz and Pz for P3) served as within-subjects factors. Figure 1 and 2 provide bar chart for the P1 and P3 ERP mean amplitudes by gender and emotional expression, respectively.

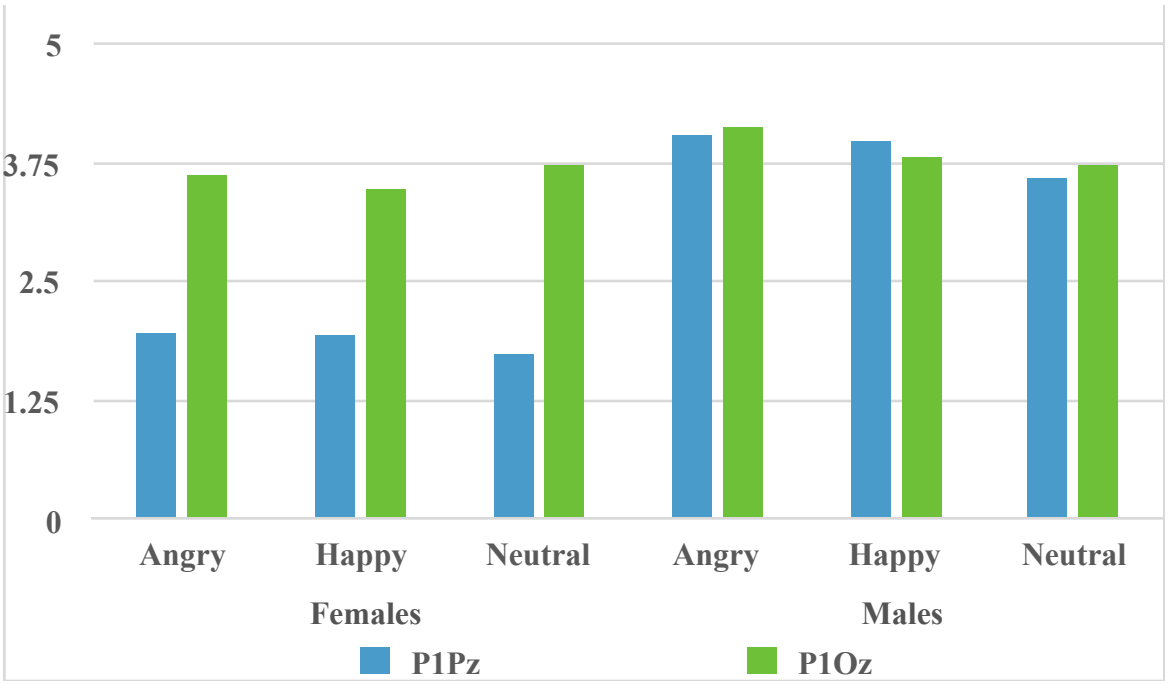

Figure 1. P1 ERP mean amplitudes by gender and emotional expression. The vertical axis reflects mean amplitudes in microvolts.

For the P1, there was no main effect of gender, $F(1,31) = 1.51$, $p = 0.229$, or channel, $F(2,62) = 2.99$, $p = 0.094$. There was an effect for emotion, $F(2,62) = 5.31$, $p = 0.007$, as well as an emotion by channel interaction, $F(2,62) = 7.78$, $p < 0.001$. This interaction was explored by examining emotional effects separately by channel. At Pz, there was an effect for emotion, $F(2,62) = 5.46$, $p = 0.007$, that was driven by greater mean amplitudes in response to angry and happy faces relative to neutral faces. There were no mean amplitude differences in response to angry and happy emotional expressions. There was also an emotion effect at Oz, $F(2,62) = 5.94$, $p = 0.004$. However, this effect was driven by greater mean amplitudes in response to angry emotional expressions compared to happy or neutral expressions, with no differences between the latter expressions.

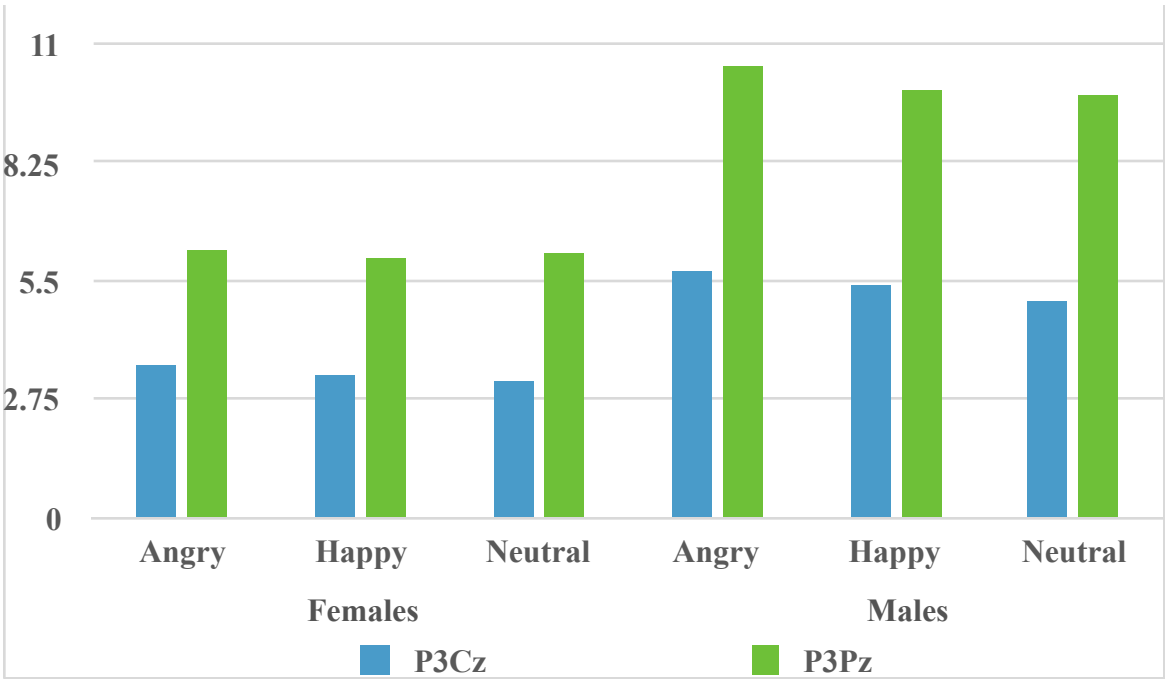

Figure 2. P3 ERP mean amplitudes by gender and emotional expression. The vertical axis reflects mean amplitudes in microvolts.

For the P3, the main effects of gender, $F(1,31) = 2.61$, $p = 0.081$, and emotion, $F(2,62) = 2.61$, $p = 0.082$, were not significant. There was a significant effect for channel, $F(2,62) = 45.39$, $p < 0.001$, in which mean amplitudes were greater at Pz than at Cz. There were no reliable interactions (p's > 0.084).t

Discussion

Using an emotion perception task while recording ERPs, we aimed to better understand the differences in emotion perception response between men and women. Contrary to our hypothesis, we found no differences based on gender. This data challenges previous ERP data that indicate a difference between men and women (Lithari et al., 2010). As mentioned previously, our design avoided several limitations to this study. First, our method of data analysis utilized the standard area-under-the-curve approach recommended by professionals in the ERP field (Luck, 2005; Woodman, 2010). Second, consistent with current emotion research, we tested for specific emotions to represent emotional valence (angry, happy, and neutral). Third, we used a greater number of stimuli per cell to ensure a clean ERP; each of the 16 experimental blocks consisted of 72 trials each, which yielded a greater number of trials in comparison to the previous study. The present study found contradicting results to Lithari et al. while avoiding several weaknesses of their experimental design. Therefore, it is worth questioning the validity of their finding

We did, however, find differences in the emotion response based on location of the channel and the type of emotion. Despite angry faces invoked a heightened amplitude in the ERP window known to reflect preconscious arousal at the occipital recording site, response times for angry faces were slower relative to happy faces. This goes against the idea that the threat perception system would induce a quicker response to threatening stimuli and suggests that behavioral data are limited in their ability to address approach/avoidant strategies related to emotion processing. The heightened amplitude of Pz at both the pre- and post-conscious level

indicates that this region in the parietal lobe is an important component in the emotion perception response.

Limitations. One limitation to this study may be a lack of cross-cultural validity. The demographic of participants in this study were likely representative of the population at the University of Akron in Akron, Ohio—young men and women, a majority of whom are white, educated, and part of a Western culture. Another limitation could be the size of the dataset (16 males and 17 females). A larger, more diverse sample may yield results that are more accurate to the population.

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