Facial attractiveness: two social constructs but where and when do they relate.

An EEG and behavioural study

**Abstract**

The aim of the study was to focus on the electrophysiological responses (neural response) to perceiving facial attractiveness to see whether emotional activity arises, starting off by giving a brief introduction on each of these three key components after which the hypothesis “will different ERPs – P100, N170, P200, and the LPP – differ in attractiveness categories and is there an effect between attractiveness and unattractiveness?” follows as this relation is not too well established. The study uses a selection of pictures – female and male; unattractive, intermediate, and unattractive – in a pseudo-randomized fashion in a 10 block, 24 stimuli per block set-up after which the data is pre-processed and analysed. Results of these analyses show that there is a difference between stimuli, difference between gender, and between attractiveness levels for the P200 ERP, answering the previously stated hypothesis as an effect is found for the P200 ERP in the form of both main effects and interaction effects.

**Introduction**

**Facial attractiveness**

Facial attractiveness is amongst the main features in social interactions, it plays a major role in both peer and mating selection. Much research – both neuronal and behavioural - has focused on determining which physical characteristics render a face attractive or not. These include averageness of a face, symmetry within a face, familiarity, skin quality, and gender-specific facial features (Schacht, Werheid & Sommer, 2008).

In turn, this results into direct and indirect positive and pleasurable effects for reproduction impulses, providing positive stimuli in the form of an attractive face or a negative stimuli in the form of an unattractive face (Schacht, Werheid & Sommer, 2008; Ferrari, Lega, Tamietto, Nadal & Cattaneo, 2015). Within evolutionary psychology, all of the features mentioned as attractiveness factors (averageness within a face, symmetry within a face, familiarity, skin quality, and gender-specific features) can act as critically biological signals in mating selection, altering reproductive success – ugliness reducing the chance at success in contrary to attractiveness of the face. From an evolutionary standpoint, the main feature being sought for is the success regarding reproductivity as it means your offspring has higher chance of existing (Wade, 2010).

The emotional expressions upon noticing facial attractiveness express themselves in the three major muscle that moves in our facial structure upon noticing attractiveness; the zygomaticus major, the corrugator, and the orbicularis oculi. All three of these major muscles are highly active in emotional expressions – raising positive emotions if attractive while raising negative emotions if unattractive (Wade, 2010). This is due to the fact that it shows demerit in developmental health and general health, which makes someone attractive.

Along with this symmetry follows averageness of a face, the colour of one’s skin along with the quality of the skin (is it monotone and without impurities). The quality and the colour of the skin shows whether a person is healthy or not (Bailey, Faulin, Agyei & Gladue, 1994).

On top of that there is sexual dimorphism; male facial characteristics such as a broad chin, a larger nose, and facial hair can arise due to feelings of attractiveness as all three of these arise from higher levels of testosterone (Bailey, Faulin, Agyei & Gladue, 1994). In females, the characteristics that are considered attractive from an evolutionary standpoints show fertility; cheekbone breadth – higher being considered more attractive due to indexing pathogen resistance – and size, lip size, hair length and quality, and the shape of the eyes (Wade, 2010). These specific facial qualities are attractive to the other sex and the reproductive purposes that come along with these qualities (Bailey, Faulin, Agyei & Gladue, 1994).

**Agreement across individuals.**

Agreement between individuals is one of the best-documented and most robust findings in facial attractiveness. Across many studies there’s been a high concordance between same sex judgements, within-culture judgements, and cross-culture judgements as to what’s attractive in facial attractiveness (Little et al., 2011). According to Little et al., (2011), cross-cultural agreement on attractiveness is evidence against the notion that attractiveness ideals are captured bit by bit by those growing up within a particular culture. This evidence suggests that there is something universal about attractive faces (and unattractive faces) that is recognized both across individuals and cultures.

Even though, one might assume facial attractiveness is only present when facing a person or image of a person for a prolonged amount of time, a study by Olson and Marshuetz (2005) showed that even when facial attractiveness was presented for a period of 13ms, a subject will still recognizes and react to the presented stimuli, despite the limited time they will be able to judge facial attractiveness. This indicates that we – human beings – register facial attractiveness rapidly and with a minimal amount of information presented (Schacht et al., 2008). Given these are all behavioural results and conclusions, it is only covering a few of many aspects that correlate with facial attractiveness – the behavioural part, the biological part, and the evolutionary part, which leaves us with the neurological and the emotional part left unspoken. So far we have covered the facial attractiveness part of our study, leaving two other main components left uncovered. In this study, we aim to find out whether emotional activity in the brain happens upon seeing facial attractiveness, this leads us to the next main component – emotions.

**Emotions**

In the studies of emotion, emotion theories play a huge role. Three of them are key in this study – the circumplex theory, the motivation model of Elliot, and the six basic emotions model of Ekman. The circumplex model (Russell, 1989) suggests that emotions are distributed in a two-dimensional circular space, containing arousal and valence dimensions. In this model, arousal represents the vertical axis and valence represents the horizontal axis, whereas the centre of this circle represents valence and arousal at a neutral and medium level respectively. In this model, emotional states can be represented at any level of valence and arousal, or at a neutral level of one or both of these factors. In their article, Ruben and Talerico (2009) mention that the circumplex model has been used most commonly to test stimuli of emotional words, emotional facial expressions, and affective states. Following a study by Posner, Russel, and Peterson (2005), it is stated that with the physiological measures associated with basic emotions differ significantly depending on the nature of the eliciting stimuli – the presented stimuli can raise either a really affective emotion or barely any affection within the emotion. Within the same study, Posner, Russel, and Peterson (2005), note that the emotional experiences often overlap and that the emotions cannot be clearly differentiated due to the lack of discrete borders, which creates polar opposites of one another and bordering emotional expressions.

The motivation model by Elliot (1997) shows us that there is an approach and avoid behaviour upon seeing a certain stimuli. The person will either show a positive emotion and illustrate approach behaviour if the stimuli or person stimuli raises positive emotions within their mind. In contrary, negative emotions raise avoid behaviour and results in negative emotions rather than positive emotions upon seeing stimuli that are negative.

On top of that, there is the six basic emotions model of Ekman (1993). In this theory Ekman (1993) labels six emotions – anger, happiness, fear, surprise, disgust, and sadness – that are readily recognized across very different cultures. These emotions are detected with ease by nearly everyone due to the explicit facial expressions they raise. The emotions can either cause positive reactions or negative reactions as seeing happiness elicits positive emotions within a person whereas fear, anger, and sadness elicit negative emotions (Posner, Russel & Peterson, 2005)

Combining these three key emotional theories as an example we can say that negative emotions awaken signs of disgust, avoidance, and low valence, whereas positive emotions wake up signs of desire, approach, and high valence within our minds (Ekman, 1993; Elliot, 1997). These emotional theories play a huge part when it comes down to facial attractiveness. Upon seeing a pretty face, one can show happiness and high valence, whereas upon seeing a face that is less pretty disgust, low valence, and avoidance can show up. Following up with study performed by Russell (2003), changes in eliciting stimuli can cause quick changes in valence, arousal, emotional expressions, and physiological activity. Seeing an attractive face right after seeing an unattractive face can change the emotional activity within our minds from negative to positive – low valence to high valence, from disgust to desire, and from avoidance to approach behaviour (Ekman, 1993; Elliot, 1997; Russell, 1989). Not only do emotions play a role upon detecting facial attractiveness, they show whether a person is attractive or not. A smile activates the three major muscles in our face (the zygomaticus major, the corrugator, and the orbicularis oculli) which in turn can show symmetry between these muscles. This shows that emotions can function as a sign of attractiveness as positive emotions and a symmetric face upon smiling is regarded as attractive, but emotions also a detector of attractiveness (Ekman, 1993; Elliot, 1997; Wade, 2010).

As emotions change upon seeing either positive or negative stimuli and thus attractiveness and unattractiveness, they can therefore be seen as the end product of a complex interaction between our cognitions. These interactions likely occur as electrophysiological changes related to the valence and arousal systems, which are largely composed out of our subcortical structures (Posner, Russell & Peterson, 2005), which links this study to the next key component – the neurological aspect.

**Electrophysiological expressions of facial attractiveness**

In previous studies, Schacht et al. (2008) reported that there’s two ERP time ranges that play a huge role in detecting facial attractiveness; N170 and P100. For example, Schacht et al. (2008) found that threatening facial expressions compared with intermediate ones evoked negativities at latencies between 200 and 320 msec after stimulus presentation while they also found “happy” expressions at the 170 msec after the initial pleasant facial expression stimulus was presented to the subject.

**N170**

The N170 component is considered to be part of attractiveness appraisal (Pizzagalli, Regard & Lehman, 1999). The P100 and the N170 are the earliest moments of registering attractiveness appraisal according to Pizzagalli et al. (1999). According to Altmann (2018), upon detecting attractive faces, the N170 elicits more negative amplitudes and thus higher activity within the brain in comparison to unattractive and intermediate stimuli – indicating that we react more intensely on attractive faces in contrary to intermediate and unattractive faces. This along with Schacht et al. (2008) reporting that “happy” expressions were found at the 170 msec mark after being presented with attractive stimuli indicates that the N170 plays a part in the attractiveness appraisal and possible emotional attention to stimuli. On top of that, in a according to a study by Blau et al. (2007), the N170 component is linked to structural encoding of face stimuli and it shows a strong modulation by emotional facial expressions contained within facial stimuli. This indicates that both positive and negative emotions raise electrophysiological activity within the N170 component.

**P100**

The P100 has been associated with early activity and early attention to visual material, with maximum amplitudes between 90 and 120 ms after stimulus onset. These amplitudes of the P100 are sensitive to basic physical stimulus characteristics, which includes facial attractiveness due to facial attractiveness containing basic physical characteristics (Luck, 2005). The amplitude of the P100 is more positive the more positive the reaction it elicits, peaking in electrophysiological when there is a more attractive stimuli presented (Sysoeva, Constantino & Anokhin, 2018). According to Batty and Taylor (2003), the P100 is the very first ERP point in time to encode facial attractiveness and is responsible for the first reflects on facial attractiveness.

**Electrophysiological expressions of emotion processing**

**P200**

The P200 has been associated with early attention to emotional stimuli, it is the earliest neural marker of emotional regulation and emotional stimuli (Fisher et al., 2010). Results from previous study have shown that different basic emotions can be differentiated in the P200, resulting in the first emotional intonations of arousal being encoded (Paulmann, Bleichner & Kotz, 2013). The P200 plays a role in early emotional recognition by the brain and it is thus one of the main ERPs when regarding the emotional responses, only followed by the later by the LPP component. This arousal and the emotional responses of the P200 is elicited for both negative and positive stimuli – it can be positively arousing but also inducing signs of fear (Fisher et al., 2010).

**LPP**

The LPP component is a late neural marker of emotional regulation and emotional stimuli. The LPP is reduced following the use of cognitive emotion regulation strategies such as reappraisal (Dennis & Hajcak, 2009). The LPP plays a role in cognitive emotion regulation and mood disruption with its main facilitated marker being the emotion regulation just like with the other components, it plays a huge role in the emotion registering within the ERPs and within the emotional regulation regarding ERPs (Dennis & Hajcak, 2009). Whereas the P100, N170, and the P200 are mainly in earlier time ranges after registering the stimuli, the LPP registers in a later stage, hence the name late positive potential.

**Facial attractiveness, emotions, and electrophysiological expressions.**

If we combine the main three constructs of this study, we find that facial attractiveness, emotions, and electrophysiological expressions of both emotional processing and facial attractiveness are closely linked. This close link comes together in this study as we aim to find out whether emotional activity and thus emotions register in our brains when we detect facial expressions. Since there is no clear answer to this, it is a necessity to explore the relation between these three as it will bring us – as humanity – closer to unveiling where and how our emotions work in electrophysiological expressions.

**Hypothesis**

Given the main purpose of our study, emotions can be seen as the end product of a interaction between cognitions and electrophysiological changes related to the valence and arousal systems. The changes related to valence and arousal systems take place upon seeing either positive or negative stimuli. These changes in our valence and arousal systems along with the facts that ERPs that play a role in emotional detection, emotion registering, detecting facial attractiveness, and detecting facial expressions are known to us, we can form a hypothesis. We form this hypothesis to narrow down whether facial attractiveness raises positive or negative electrophysiological emotional activity within our brains. This hypothesis will thus be answering whether the ERPs that are aligned with the emotional detection and the emotional responses have emotional activity upon detecting facial attractiveness. This leads us to a hypothesis for this study based on emotions, facial attractiveness, and the neurological substrates that align with the ERPs: “Emotional activity in the P100, N170, P200, and LPP ERPs when detecting facial attractiveness”. This hypothesis came forth from the research question “will different ERPs – P100, N170, P200, and the LPP – differ in attractiveness categories and is there an effect between attractiveness and unattractiveness?”

**Method**

**Participants**

For this experiment, there was a total of 40 participants – 26 females, 14 males – selected. The age of these participants ranged from 18 to 30 with the mean age being 20.7, while the standard deviation was 2.64. The participants were recruited via the PURS system in which registration for the EEG experiment was handled. As a reward, the participants received 2 hours towards their “participant” hours (a requirement for the course Academic Skills in year 1 of the psychology study by Tilburg University).

**Stimuli**

The visual stimuli within the experiment were presented in a way that a picture of either an attractive, an average, or an unattractive face would appear in the middle of the 244hz Dell monitor for a period of 1000ms, this was either a male or a female face. The stimuli were mugshots from a database, these were then photoshopped to be made unrecognizable. This then turned into the three categories (attractive, average, unattractive).

**Design**

The design applied to this experiment is a within-subject design. A subject is tasked with rating attractiveness on different levels for both men and women – intermediate, unattractive, and attractive. They are presented with these three categories and have to rate, without their knowledge that these categories exist. These three categories were pseudo-randomized amongst the blocks, there were 4 attractive males, 4 unattractive males, 4 attractive females, 4 unattractive females, and 4 for both male and female in a intermediate attractiveness. The stimuli were presented in a random fashion from a selection and presented in a random order within the blocks. Before being tasked with 10 blocks of these 24 images, the subject is provided with a practice block of 12 stimuli in which he/she is presented with a a fixation cross (1000ms), then an image (1000ms), then there’s a small delay (200ms), after which he/she is given a 5000ms window to move a slider to the right (attractive) or the left (not attractive) before pressing a button beneath the slider saying “next” and moving on to the next stimuli. It is crucial for the subject to press “next” or else the data will be lost, hence the participant is informed before starting to ensure that they press the “next” button.

**Procedure**

Once the participant arrived at the experiment, they were presented with an informed consent and an information letter of what will happen to them during the experiment. Once they read the form of consent, they were asked to sign the form of consent with an autograph, which in turn the form of consent was autographed by an experimenter. Participants were then asked to sit on a comfortable desk chair so that the process of attaching all the sensors could begin. Before placing the 64 electrode EEG cap on top of the subject’s head,2 electrodes are placed on the subject’s mastoids to ensure a reference point is established for the data analysis. On top of that, skin conductance is applied to the index and middle finger of the non-dominant hand (left hand in case of right-handed dominance, right hand in case of left-handed dominance) with two electrodes placed on top of them around 10-15 minutes before the EEG begins so that the skin conductance has enough time to start working. After the mastoids and the skin conductance is in place, the participant’s head is measured from just above their eyebrows to the back of their cranium to see which size of EEG cap their skull requires. The subject will have to wear a fitting cap so they will be as comfortable as possible during the experiment. With the cap in place, Parker conductance gel is placed within every hole of the EEG cap, resulting into conductance being possible without interference. Once all the electrodes of the cap are in place, there’s an additional set of 4 electrodes that are placed around the subject’s eyes - 3 on the right side of the individual’s face (one above, one below, and one to the right), and 1 on the left side left of the eye – for these the subject is asked to look in front of them so that the electrodes are in symmetry with the pupil. These electrodes are to measure the movement of the eyes and record blinks for EOG data. When all these electrodes are in place, the participant is asked to smile, revealing the zygomaticus major to the experimenters. Knowing were the facial muscles are, an alcohol wipe is used to clean the skin. Afterwards, 2 electrodes are placed on top of each major muscle – the zygomaticus major, the corrugator, and the orbicularis oculi.

With all the electrodes in place, the subject is asked to take a seat in a near sound-proof cabin with a computer and a 244hz monitor to ensure there is as little latency as possible. We conducted a test made with E-prime, one that regarded attractiveness. In these tests, the subject is provided with a practice block of 12 stimuli in which he/she is tasked to practice and to ensure that they managed to get the hang of it as pressing “next” within the 5000ms time window is a crucial part for the data to be usable. Once the practice block is completed by the test subject, electrodes are adjusted if necessary due to unstable or irregular activity of the electrodes within Actiview. Following this, the subject is presented with 10 blocks of 24 stimuli and is tasked to rate the pictures they are shown. Once the participant reaches the middle of the experiment, they are asked if they want anything to drink and a second check on the electrodes is performed.

**Recordings**

The experiment itself was created in E-Prime, the EOG and EEG data was corrected for in BrainVision Analyzer 2.0. First off, the mastoids were set as a reference point instead of point CMS and DRL. Second of all, a bipolar EOG was set up to boost the signal and ensure everything was readable. Third of all, the node filters 0.1-100Hz were applied to filter two noises – slow drift (resistance of amplitude) and very high frequencies caused by muscle action. Fourth, all the non-EEG channels were removed, this included the eye movement channels and skin conduction. Fifth in the pre-processing was the segmentation of all conditions. In this step of pre-processing, the segments that are not related to the processing of the stimuli were removed (-1000 to 2000 ms). Sixth, the EOG correction for eye movements was performed. Seventh, the baseline was established. The channels were placed in the center 200ms before the onset of the stimulus by taking the average and subtracting it from the entire segment otherwise it would create noise. Eight of all, the artefacts were rejected. In the artefact rejection part, there was manually looking through all the data following the interval of -200 to 1200 ms with the minimum and maximum allowed amplitudes being -500 to 500 uV. The last two steps of the pre-processing were filtering 0.1 - 3 Hz and then averaging the channels to create the ERPs necessary for statistical analysis.

**Data analysis**

The data from BrainVision Analyzer was then imported into SPSS for data analysis. All the data analysis was performed within IBM’s SPSS, allowing the experiment to be replicated with ease given the repeated measures ANOVA’s performed on the data. For the data analysis we used the mean amplitudes for following time windows for each ERP respectively: N170 (150-160ms), LPP (600-1100ms), P1(90-100ms), P200(145-155ms).

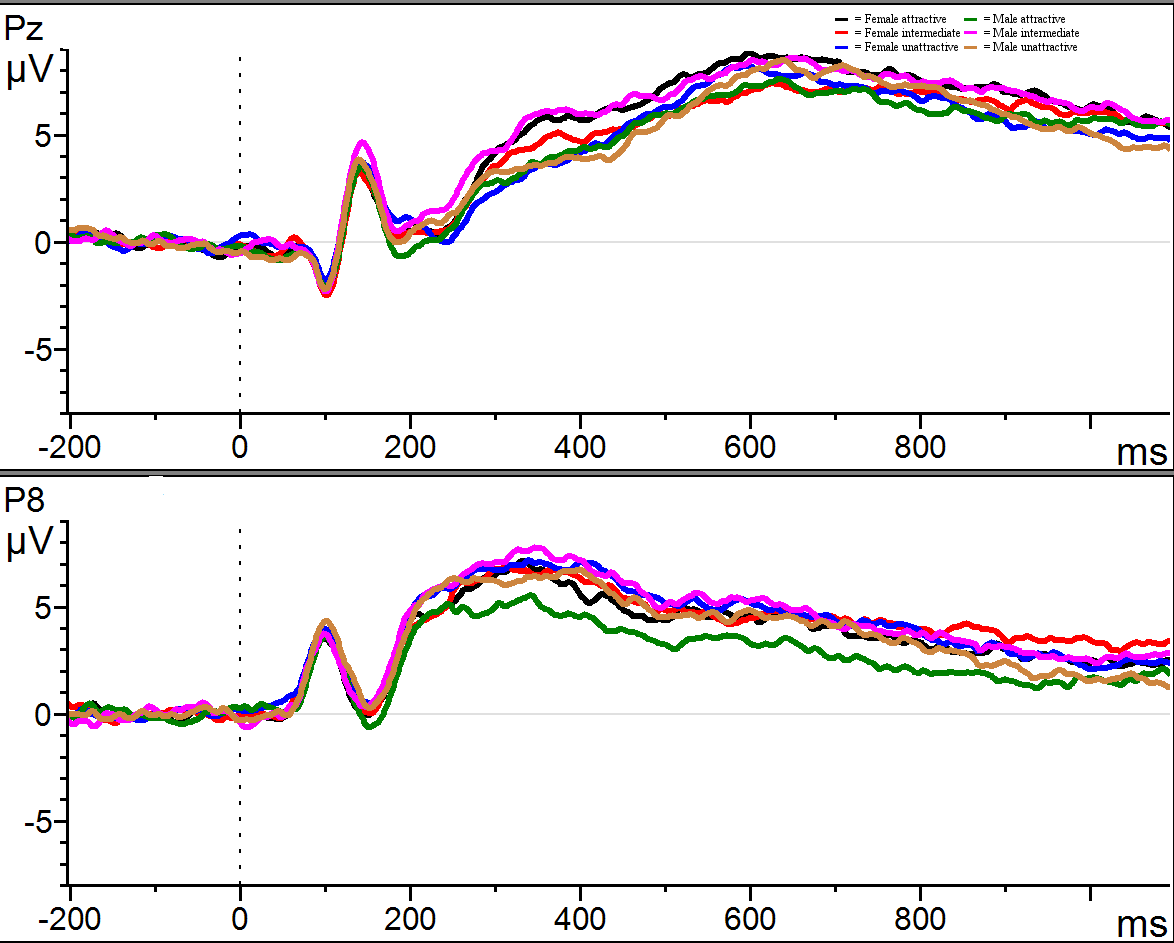
**Behavioural analysis**

Following the pilot study for this study in which students picked attractive, intermediate, and unattractive pictures of both females and males, all the individual ratings of female attractive, female intermediate, female unattractive, male attractive, male intermediate, and male unattractive pictures were combined into their respective means. With these means a repeated measures ANOVA with two within-subject factors - image gender and image attractiveness - along with a between-subject level containing the subject their sex to see whether there’s a significant effect between unattractive, intermediate, and attractive stimuli and whether the subject their sex matters. Two analyses that followed were corrected according to the Greenhouse-Geiser method while a Repeated contrast was applied to compare unattractive to attractive and attractive to intermediate.

**Statistical analysis**

Finally, for the LPP, N170, P1, and P200, a repeated measures ANOVA with two within-subject factors - image gender and image attractiveness - along with a between-subject level that contained the subject their sex. Due to scalp distribution and research done in a previous study by Ma, Hu, Jiang, and Meng (2015), the LPP, P1, and P200 were analysed based on six electrode sites (CP3, CPz, CP4, P3, Pz, and P4) in the central-parietal areas. Deducted from a study by Trujillo, Jankowitsch, and Langlois (2014), the N170 was analysed following eight temporal-occipital scalp sites (P7, P8, PO7, PO8, P5, P6, TP7, and TP8). The actual analyses were corrected according to the Greenhouse-Geiser method while there was also a Helmert contrast used when a significant within-subjects effect was found. On top of that, a simple-effect test with a Bonferonni correction was used for the P200 multiple regression ANOVA.

**Results**

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*Figure 1: electrophysiological activity for two of the ERPs used in the analyses; one used for the N170 analyses (P8) and the other used in the analyses for P100, P200, and the LPP (Pz).*

**Behavioural results**

Table 1.

Behavioral results - Multivariate test.

|  |  |  |  |
| --- | --- | --- | --- |
| Effect | *F* | *df* | *P* |
|  |  |  |  |
| ImgGender | 1.876 | 38 | .179 |
|  |  |  |  |
| ImgAttractiveness | 310.211 | 38 | .000\*\* |
|  |  |  |  |
| ImgGender \* Sex | .290 | 37 | .593 |
|  |  |  |  |
| ImgAttractiveness \* Sex | .176 | 37 | .839 |
|  |  |  |  |
|  |  |  |  |
| ImgGender \* ImgAttractivness | 9.409 | 37 | .000\* |
|  |  |  |  |
| ImgGender \* ImgAttractiveness \* Sex | 1.096 | 37 | .345 |
| \*= a significant interaction effect  \*\*= a significant main effect  All findings are at a p<0.05 level. |  |  |  |

Table 2.

Behavioral results - test of within-subjects contrasts.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Effect | ImgGender | ImgAttractiveness | *F* | *df* | *P* |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
| ImgAttractiveness |  | Attractive vs. intermediate | 265.037 | 1 | .000\*\* |
|  |  | Intermediate vs. unattractive | 495.235 | 1 | .000\*\* |
| ImgGender \* ImgAttractiveness | Male vs. Female | Attractive vs. intermediate  Intermediate vs unattractive | .014  18.383 | 1  1 | .905  .000\* |
|  |  |  |  |  |  |
| \*= a significant interaction effect  \*\*= a significant main effect  All findings are at a p<0.05 level. |  |  |  |  |  |

*Figure 2: the averages given to both male and female attractive, intermediate, and unattractive stimuli by female subjects with a 95% CI.*

*Figure 3: the averages given by male students for each condition with a 95% CI.*

Following the repeated measures ANOVA, a significant main effect was found for image attractiveness (*F*(1,38) = 310.211, *p* < 0.05) and a significant interaction effect was found for the interaction between attractiveness with gender (*F*(1,37) = 9.409, *p* < 0.05). The Repeated contrast revealed a significant main effect between the intermediate and the unattractive condition (F(1,38) = 495.235, *p* < 0.01) and the attractive and the intermediate condition for image attractiveness (*F*(1,38) = 265.037, *p* < 0.01), which is shown in table 2, figure 2, and figure 3.

**LPP**

Table 3.

LPP results - Multivariate test.

|  |  |  |  |
| --- | --- | --- | --- |
| Effect | *F* | *df* | *P* |
|  |  |  |  |
| ImgGender | .040 | 36 | .843 |
|  |  |  |  |
| ImgAttractiveness | .111 | 35 | .896 |
|  |  |  |  |
| ImgGender \* Sex | .432 | 36 | .515 |
|  |  |  |  |
| ImgAttractiveness \* Sex | .698 | 35 | .505 |
|  |  |  |  |
|  |  |  |  |
| ImgGender \* ImgAttractivness | .406 | 35 | .670 |
|  |  |  |  |
| ImgGender \* ImgAttractiveness \* Sex | 1.441 | 35 | .250 |
| \*= a significant interaction effect  \*\*= a significant main effect  All findings are at a p<0.05 level. |  |  |  |

*Figure 4: the average electrophysiological activity in microvolt for female subjects per condition with a 95% CI for the LPP ERP.*

*Figure 5: the average electrophysiological activity in microvolt for male subjects per condition with a 95% CI for the LPP ERP.*

The repeated measures ANOVA revealed no significant main effect for image gender (*F*(1, 36) = 0.040, *p* = .843), indicating that there is no significant activity change regarding LPP amplitudes when regarding sex of the participant after having taken the average LPP amplitude computed per category by taking the means of the selected electrodes. For none of the other interactions nor attractiveness was there a significant effect; attractiveness (*F*(1,35) = 0.111, *p* = .896), interaction of gender with sex of the participant (*F*(1,36) = <0.432>, *p* = .515), attractiveness with sex (*F*(1,35) = 0.698, *p* = .505), gender and attractiveness (*F*(1,35) = 0.406, *p* = .670), and gender and attractiveness with sex of the participant (*F*(1,35) = 1.441, *p* = .250).

**P1**

Table 4.

P1 results - Multivariate test.

|  |  |  |  |
| --- | --- | --- | --- |
| Effect | *F* | *df* | *P* |
|  |  |  |  |
| ImgGender | .194 | 36 | .662 |
|  |  |  |  |
| ImgAttractiveness | .702 | 35 | .502 |
|  |  |  |  |
| ImgGender \* Sex | 1.617 | 36 | .212 |
|  |  |  |  |
| ImgAttractiveness \* Sex | .310 | 35 | .735 |
|  |  |  |  |
|  |  |  |  |
| ImgGender \* ImgAttractivness | .377 | 35 | .689 |
|  |  |  |  |
| ImgGender \* ImgAttractiveness \* Sex | .736 | 35 | .486 |
| \*= a significant interaction effect  \*\*= a significant main effect  All findings are at a p<0.05 level. |  |  |  |

*Figure 6: the average electrophysiological activity in microvolt for female subjects per condition with a 95% CI for the P1 ERP.*

*Figure 7: the average electrophysiological activity in microvolt for male subjects per condition with a 95% CI for the P1 ERP.*

For P1 the same repeated measures ANOVA was performed with the same electrodes being picked along with the same factors. None of the interactions nor the main factors gave a significant effect. Gender (*F*(1,36) = 0.194, *p* = .662), gender with sex of the participant interaction (*F*(1,36) = 1.617, *p* = .212), attractiveness (*F*(1,35) = 0.702, *p* = .502), attractiveness with sex of the participant interaction (*F*(1,35) = 0.310, *p* = .735), gender and attractiveness interaction (*F*(1,35) = 0.377, *p* = .689), gender and attractiveness with sex of the participant interaction (*F*(1,35) = 0.736, *p* = .486). Following figure 6 and figure 7, a significant effect between male and female subjects in electrophysiological activity was found (*F*(1,36) = 2.867, *p* < 0.1).

**P200**

Table 5.

P200 results - Multivariate test.

|  |  |  |  |
| --- | --- | --- | --- |
| Effect | *F* | *df* | *P* |
|  |  |  |  |
| ImgGender | 4.295 | 36 | .045\*\* |
|  |  |  |  |
| ImgAttractiveness | .425 | 35 | .657 |
|  |  |  |  |
| ImgGender \* Sex | 1.323 | 36 | .258 |
|  |  |  |  |
| ImgAttractiveness \* Sex | 1.800 | 35 | .180 |
|  |  |  |  |
|  |  |  |  |
| ImgGender \* ImgAttractivness | 5.402 | 35 | .009\* |
|  |  |  |  |
| ImgGender \* ImgAttractiveness \* Sex | 1.034 | 35 | .366 |
| \*= a significant interaction effect  \*\*= a significant main effect  All findings are at a p<0.05 level. |  |  |  |

Table 6.

P200 results - test of within-subjects contrasts.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Effect | ImgGender | ImgAttractiveness | *F* | *df* | *P* |
|  |  |  |  |  |  |
| ImgGender | Male vs. Female |  | 4.295 | 1 | .045\*\* |
|  |  |  |  |  |  |
|  |  |  |  |  |  |
| ImgGender \* ImgAttractiveness | Male vs. Female | Attractive vs. later levels  Intermediate vs unattractive | .479  10.445 | 1  1 | .493  .003\* |
|  |  |  |  |  |  |
| \*= a significant interaction effect  \*\*= a significant main effect  All findings are at a p<0.05 level. |  |  |  |  |  |

Table 7.

P200 – ImgGender \* ImgAttractiveness simple effects test with a Bonferroni

**Image Gender ImgAttr (1) ImgAttr (2) *Mean diff (1-2) Std Error P***

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Female  Male | Attractive  Intermediate  Unattractive  Attractive  Intermediate  Unattractive | Intermediate  Unattractive  Attractive  Unattractive  Attractive  Intermediate  Intermediate  Unattractive  Attractive  Unattractive  Attractive  Intermediate | .386  -.439  -.386  -.824  .439  .824  -.772  -.007  .772  .765  .007  -.765 | .392  .415  .392  .389  .415  .389  .340  .419  .340  .356  .419  .356 | .996  .892  .996  .123  .892  .123  0.88  1.000  .088  .115  1.000  .115 |

\*= a significant interaction effect

\*\*= a significant main effect

All findings are at a p<0.05 level.

Table 8

Multivariate test ImgGender.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Female  Male | 2.187  3.734 | 35  35 | .127  .034\*\* |  |

**Image Gender *F df P***

\*= a significant interaction effect

\*\*= a significant main effect

*Figure 8: the average electrophysiological activity in microvolt for female subjects per condition with a 95% CI for the P200 ERP.*

*Figure 9: the average electrophysiological activity in microvolt for male subjects per condition with a 95% CI for the P200 ERP.*

For the P200, the same repeated measures ANOVA was performed as with the P1 and the LPP sections; the same factors, the same electrodes, along with the same descriptive statistics and measures. Unlike with the P1 and the LPP, a significant effect was found with gender alone (*F*(1,36) = 4.295, *p* < 0.05), and the interaction of gender and attractiveness (*F*(1,35) = 5.402, *p* < 0.001). Whereas there were no other significant interactions – the interaction of gender with sex of the participant (*F*(1,36) = 1.323, *p* = 0.258), attractiveness (*F*(1,35) = 0.425, *p* = 0.657), attractiveness and sex of the participant (*F*(1,35) = 1.800, *p* = 0.180), and gender and attractiveness with sex of the participant (*F*(1,35) = 1.034, *p* = 0.366). On top of that, the Helmert contrast showed significance on the main effect of gender and the interaction effect of gender and attractiveness (see table 6). The simple-effect test revealed a significant effect on the male condition within image gender (*F*(1,35) = 3.734, p < 0.05) while displaying no significant effect for the female condition (see table 8). For image attractiveness, the simple-effect test found no significant effects (see table 7).

**N170**

Table 9.

N170 results - Multivariate test.

|  |  |  |  |
| --- | --- | --- | --- |
| Effect | *F* | *df* | *P* |
|  |  |  |  |
| ImgGender | .033 | 36 | .857 |
|  |  |  |  |
| ImgAttractiveness | .390 | 35 | .680 |
|  |  |  |  |
| ImgGender \* Sex | .938 | 36 | .339 |
|  |  |  |  |
| ImgAttractiveness \* Sex | 1.433 | 35 | .252 |
|  |  |  |  |
|  |  |  |  |
| ImgGender \* ImgAttractivness | 1.915 | 35 | .162 |
|  |  |  |  |
| ImgGender \* ImgAttractiveness \* Sex | .412 | 35 | .665 |
| \*= a significant interaction effect  \*\*= a significant main effect  All findings are at a p<0.05 level. |  |  |  |

*Figure 10: the average electrophysiological activity in microvolt for female subjects per condition with a 95% CI for the N170 ERP.*

*Figure 11: the average electrophysiological activity in microvolt for male subjects per condition with a 95% CI for the N170 ERP.*

The N170 had a different selection of electrodes sites (P7, P8, PO7, PO8, P5, P6, TP7, and TP8), resulting in no significant effect being found for the main effects – image gender and image attractiveness – nor were there significant effects being found for any of the interactions in the multivariate analysis (see table 7). Following figure 10 and figure 11, it is shown that there is a significant effect between subjects their sex in electrophysiological activity per condition (*F*(1,36) = 3.431, *p* < 0.1), both being far different from one another.

**Discussion**

The study examined the neural responses to perceiving facial attractiveness for several categories (unattractive, attractive, and intermediate) for both genders. The main research question was whether different ERPs – P100, N170, P200, and the LPP – would differ in attractiveness and whether there’s an effect between attractive and unattractive faces and the main hypothesis was that these ERPs would show more activity when seeing an attractive face in comparison to an unattractive face. The analysis performed on the behavioural data supports the idea that there is a significant effect for the attractiveness ratings the subjects gave the images. The repeated contrast and the figures showed that there was a significant effect between the attractive and unattractive stimuli, the attractive and the intermediate stimuli, and the intermediate and the attractive stimuli.

**Most important findings**

This study showed that the subjects had significant effect for the electrophysiological activity of P200 on gender, more specifically on the male images presented in the study, and the interaction of the image gender with image attractiveness. There was a significant effect in electrophysiological activity in recognizing intermediate stimuli and unattractive stimuli and the difference between them resulted in a significant effect in an interaction effect of image gender and image attractiveness. On top of that, the Helmert contrast revealed that there is a significant interaction effect between the intermediate and the unattractive condition.

The main effect shows that there is emotional activity in the P200 section for the selected electrodes within the analyses, it supports the idea that emotional responses and arousal play a part in the P200 time range upon seeing the gender (male or female) as there is a higher activity within the electrophysiological responses upon seeing the stimuli. This effect can be explained by the P200 being an onset marker of arousal and the earliest marker of emotional activity, which explains the difference between the gender of the images and the electrophysiological difference when presented with these genders.

Therefore, it supports the idea that the P200 is one of the first neural markers of emotional activity and arousal, given that the electrophysiological activity showed to be significant when presented with the male images within the study, however, it is not possible to determine whether the emotional activity is positive or negative as the significant interaction effect appeared betwixt the intermediate and the unattractive categories.

The between-subjects effect for N170 and P1 shows that there is a significant effect betwixt male and female subjects their electrophysiological activity of the presented stimuli with the male subjects having less electrophysiological activity than female subjects when presented with attractive, intermediate, and unattractive stimuli. In contrary to the P200 supporting the hypothesis, the N170, P1, and the LPP did not support the hypothesis in that the electrophysiological activity did not differ between attractiveness categories. None of the three – N170, P1, and the LPP – were in line with the hypothesis.

**Comparison with literature**

Contrary with the literature found, there was not a single significant effect found in the P100 and LPP in facial attractiveness and thus an emotional awakening. While Dennis and Hajcak (2009) found a relation between attractive and unattractive stimuli and the emotion that followed within the LPP time range, there was not a single effect for the data presented in the current study, the LPP did not present any significant effect between attractiveness categories.

Unlike Pizzagalli et al. their study regarding the P100 time range, the current study did not find a significant effect in this time range regarding emotional activity upon detecting attractiveness or unattractiveness. Sysoeva et al. (2018) reported that the P100 ERP will elicit more positive electrophysiological activity the more positive the reaction to the face is, meaning that attractive faces should elicit more positive electrophysiological activity however, in the current study no evidence for that was found. In contrary to these two studies, the current study did not find a significant effect between attractive, intermediate, and unattractive faces.

The study follows the study from Blau et al. (2007) in that there was no emotional activity for the N170, which reinforces Blau et al. (2007) their statement that the N170 ERP focuses on face processing and encoding stimuli within faces as our study used neutral expressions. In contrary to Schacht et al. (2008), Pizzagalli (1999), and Altmann (2018), the current study did not find any sign of the N170 ERP detecting facial attractiveness as there were no significant effects found for any attractiveness categories nor were there signs of more negative amplitudes upon registering attractive faces or ‘happy’ expressions as found by Schacht et al. (2008).

The current study aligns with the study of Shacht et al. (2008) in that it found significant effects in the P200 section when it came to image gender, and image gender and attractiveness. This is reinforced by the study performed by Paulmann et al. (2013), who used recording to detect emotional activity within the P200. They used different frequencies in mhz. to detect emotions within the P200. While the current study is not focused on recording, it is focused on emotional activity when faced with attractive stimuli and unattractive stimuli, which is what Paulmann et al. did in their study with prosody in contrary to images.

The implications of these results lead to further reinforcement of the P200 component being a part of the emotional recognition system that was backed up by several studies before the current study. However, with the implication also follows that the P200 component plays a part in recognizing facial attractiveness and reacting to the facial attractiveness correspondingly with the appropriate emotions – there being a significant difference between the unattractive and the attractive condition – which falls in line with the study performed by Shacht et al. (2008).

**Limitations**

The limitation of this study regards the subjects. The subjects selected were mainly students, thus fairly young individuals ranging from 18-30 in age, which means that it cannot be generalized across the entire population due to the age and status of the subjects that took part in the study, however, as this study was performed at a university it is a logical limitation.

Secondly, while images can function as an emotional marker, it is a static representation and as shown by Paulmann et al. (2013), recordings can also function as an emotional marker.

On top of this, there is the limitation that it is indiscernible whether the significant interaction effect within the P200 ERP was there due to positive emotional activity or negative emotional activity.

It is for these reasons that a further ERP study regarding facial attractiveness and emotions should have a demographic that covers a larger base of the population rather than a specific group, more attention should be spent to measuring arousal and valence - possibly via skin conduction – to discern whether the emotional activity is negative or positive for the P200 ERP, and audio recordings or video recordings should be used so the combination of audible and visible stimuli can both be combined to narrow down the emotional activity and discern emotions from one another.

**Conclusion**

The most important finding of the study is that facial attractiveness has an effect of emotional activity on the P200 time range, which falls in line with the studies performed by other researchers. This points out towards support for emotional recognition and emotion responses being within these time ranges. The finding relates to facial attractiveness as the facial stimuli presented resulted in either positive reactions or negative reactions and the brain activity related to it. With the significant effect between the intermediate and the unattractive stimuli being found, it is indiscernible to see which kind of emotional activity plays a part during the task the subjects were given. Due to the limitations of this study, it is not possible to generalize to the entire population nor is it possible determine whether the emotional activity was positive or negative. It is for this reason that there further research should focus on delving into discerning the emotional activity of the P200 when presented with both positive and negative stimuli.

Altmann, C. S. (2018). The influence of facial attractiveness on recognition memory: behavioural findings and electrophysiological evidence. *Friedrich-Schiller-Universität Jena*. [10.22032/dbt.33926](https://doi.org/10.22032/dbt.33926)

Batty, M. & Taylor, M. J. (2003). Early processing of the six basic emotional expressions. Cognitive Brain Research, *17*, 613-620. doi:10.1016/S0926-6410(03)00174-5

Berridge, K. C., Robinson, T. E., & Aldridge, J. W. (2009). Dissecting components of reward: “liking”, “wanting”, and learning. *Current Opinion in Pharmacology*, *9*(1), 65–73. http://doi.org/10.1016/j.coph.2008.12.014

Bailey, J. M., Gaulin, S., Agyei, Y., & Gladue, B. A. (1994). Effects of gender and sexual orientation on evolutionarily relevant aspects of human mating psychology. *Journal of Personality and Social Psychology, 66(6)*, 1081-1093.

[http://dx.doi.org/10.1037/0022-3514.66.6.1081](http://psycnet.apa.org/doi/10.1037/0022-3514.66.6.1081)

Blau, V. C., Maurer, U., Tottenham, N., & McCandliss, B. D. (2007). The face-specific N170 component is modulated by emotional facial expression*. Behavioral and brain functions : BBF, 3,* 7. doi:10.1186/1744-9081-3-7

Chatterjee, A., Thomas, A., Smith, S.E., & Aguirre, G.K., (2009). The neural response to

facial attractiveness. *Neuropsychology 23 (2)*, 135–143.

Dennis, T. A., & Hajcak, G. (2009). The late positive potential: a neurophysiological marker for emotion regulation in children. *Journal of child psychology and psychiatry, and allied disciplines, 50(11),* 1373-83.

Eimer, M., Holmes, A.J., & Mcglone, F.P. (2003). The role of spatial attention in the processing of facial expression: an ERP study of rapid brain responses to six basic emotions. *Cognitive, affective & behavioral neuroscience, 3 2*, 97-110. DOI: 10.3758/CABN.3.2.97

Ekman, P. (1993). Facial expression and emotion. *American Psychologist, 48*(4), 384-392.

[http://dx.doi.org/10.1037/0003-066X.48.4.384](http://psycnet.apa.org/doi/10.1037/0003-066X.48.4.384)

Elliot, A. J., & Church, M. A. (1997). A hierarchical model of approach and avoidance achievement motivation. *Journal of Personality and Social Psychology, 72(1)*, 218-232.

[http://dx.doi.org/10.1037/0022-3514.72.1.218](http://psycnet.apa.org/doi/10.1037/0022-3514.72.1.218)

Ferrari, C., Lega, C., Tamietto, M., Nadal, M., & Cattaneo, Z. (2015). I find you more

attractive … after (prefrontal cortex) stimulation. *Neuropsychologia, 72*, 87-93. doi:10.1016/j.neuropsychologia.2015.04.024

Fisher, J. E., Sass, S. M., Heller, W., Silton, R. L., Edgar, J. C., Stewart, J. L., & Miller, G. A. (2010). Time course of processing emotional stimuli as a function of perceived emotional intelligence, anxiety, and depression. *Emotion,10*(4), 486-97. [10.1037/a0018691](https://dx.doi.org/10.1037%2Fa0018691)

Ma, Q., Hu, Y., Jiang, S., & Meng, L. (2015). The undermining effect of facial attractiveness on brain responses to fairness in the Ultimatum Game: an ERP study. *Frontiers in neuroscience, 9,* 77. doi:10.3389/fnins.2015.00077

Paulmann, S., Bleichner, M., & Kotz, S. A. (2013). Valence, arousal, and task effects in emotional prosody processing. *Frontiers in psychology*, *4*, 345. doi:10.3389/fpsyg.2013.00345

Pizzagalli, Diego & Regard, Marianne & Lehmann, D. (1999). Rapid emotional face processing in the human right and left brain hemispheres: an ERP study. *Neuroreport. 10*. 2691-8. 10.1097/00001756-199909090-00001.

Posner, J., Russell, J. A., & Peterson, B. S. (2005). The circumplex model of affect: an integrative approach to affective neuroscience, cognitive development, and psychopathology. *Development and psychopathology*, *17*(3), 715-34. doi: 10.1017/S0954579405050340

Russell, J., Lewicka, M., & Niit, T. (1989). A cross-cultural study of a circumplex model of affect. *Journal of Personality and Social Psychology 1989, Vol. 57, No. 5*, 848-856 DOI: 10.1037/h0077714

Langlois, J. H., Kalakanis, L., Rubenstein, A. J., Larson, A., Hallam, M., & Smoot, M.

(2000). Maxims or myths of beauty? A meta-analytic and theoretical review. *Psychological Bulletin, 126*, 390-423. doi:10.1037//0033-2909.126.3.390

Little, A. C., Jones, B. C., DeBruine, L. M. (2011). Facial attractiveness: evolutionary based research. *Philos Trans R Soc Lond B Biol Sci 366 (1571),* 1638-59. doi: 10.1098/rstb.2010.0404

Luck, S. J. (2005). An introduction to the event-related potentials technique. *Cambridge: MIT*

*Press.*

Olson, I. R., & Marshuetz, C. (2005). Facial attractiveness is appraised in a glance. *Emotion, 5 4*, 498-502. DOI: [10.1037/1528-3542.5.4.498](https://doi.org/10.1037/1528-3542.5.4.498)

Rubin, D. C.; Talerico, J.M. (2009). A comparison of dimensional models of emotion. *Memory. 17* *(8)*: 802–808. doi:10.1080/09658210903130764.

Russell J. A. (2003). Core affect and the psychological construction of emotion. Psychological Review. *110,* 145–172.

Schacht, A., Werheid, K., & Sommer, W. (2008). The appraisal of facial beauty is rapid but

not mandatory. *Cognitive, Affective, & Behavioral Neuroscience, 8*, 132-142. doi:10.3758/cabn.8.2.132

Schacht, A. & Sommer, W. (2009). Time course and task dependence of emotion effects in word processing. *Cognitive, Affective, & Behavioral Neuroscience*, *9*: 28. <https://doi.org/10.3758/CABN.9.1.28>

Sysoeva, V. A., Constantino, N. J., & Anokin, P. A. (2018). Event-related potential (ERP) correlates of face processing in verbal children with autism spectrum disorders (ASD) and their first-degree relatives: a family study. *Molecular Autism, 9(41)*. <https://doi.org/10.1186/s13229-018-0220-x>

Trujillo, L. T., Jankowitsch, J. M., & Langlois, J. H. (2014). Beauty is in the ease of the beholding: a neurophysiological test of the averageness theory of facial attractiveness. *Cognitive, affective & behavioral neuroscience, 14(3)*, 1061-76. doi:[10.3758/s13415-013-0230-2](https://dx.doi.org/10.3758%2Fs13415-013-0230-2)

Wade, J. (2010). The relationships between symmetry and attractiveness and mating relevant decisions and behavior: a review. *Symmetry 2*, (2). doi: 10.3390/sym2021081