UNIVERSITY OF PADOVA

Department of General Psychology

Bachelor's Degree Course in Psychological Science

Final dissertation

Disclosing the association between empathy and emotion: A correlation ERP study

Supervisor
Professor Chiara Spironelli

Co-supervisor
Doctor Zaira Romeo

Candidate
Le Ngoc Khanh Linh

Student ID number
1222485

Academic year 2021-2022

Acknowledgements

I would like to sincerely thank my supervisors, Professor Chiara Spironelli and Doctor Zaira Romeo, for all they have done in helping me search this point. I have learnt a great deal from them throughout this internship and iI am ever grateful for all of their guidance and support.

I would also like to thank my family for putting up with my lacks of confidence and always being there to cheer me up when things were particularly tough.

Table of contents

Abstract

Empathy and emotional reactivity are both vital process for effective social functioning and emotional wellbeing. This study aimed to investigate the potential effects of both empathy traits and gender on the behavioral and psychophysiological responses to emotional stimuli. The experiment was conducted with forty participants, divided into two groups including twenty females and twenty males while they passively viewed five emotional stimulating images (Erotic, Fear, Mutilation, Extreme sports, and Neutral). Cortical activities as well as subjective evaluation of emotional stimuli were recorded. In addition, all subjects completed self-report questionnaire for assessing their empathy traits (Interpersonal Reactivity Index - IRI). Analysis of self-reports revealed that men overall perceived greater pleasantness in all affective stimuli than women, and felt more aroused to Erotic pictures, whereas women showed higher arousal for Mutilation images. Concerning ERP data, Erotic and Mutilation pictures elicited greater P1 amplitude compared with neutral images, and, regardless of stimulus content, females showed greater P1 amplitude in the right parieto-occipital sites than males. Furthermore, men had significant negative and positive correlations between specific subscales of trait empathy and the P1 neural generators of Mutilation and Erotic images, respectively, whereas women showed a negative correlation with the total IRI score and the P1 neural generator of Mutilation picture only. The result of P300 component analysis revealed Sport images induced highest amplitude and Erotic pictures elicited lowest P300 activity regardless of gender. For this component, no significant correlations appeared for men, whereas women showed a significant positive correlation featuring specific empathy dimension scores and the P300 neural generators of Erotic images.

CHAPTER 1: INTRODUCTION

1.1 General introduction

Empathy and emotion mainly have been considered separately. However, during the past few years with an increasing investigation in the field of empathy-emotion interaction, these processes are aware as being closely related. Both empathy and emotion are integral parts of human being that are extremely vital for effective social functioning and wellbeing. Empathy in its simplest form is the capacity to recognize, understand and share another's emotion. Ultimately this ability enables people to build social connection and developing good relationships. On the other hand, we – as human being – have many types of emotions that can significantly impact on how we live and interact with others. In other words, we are basically ruled by these emotions. The decision we make, the actions we take, and the perceptions we possess are all influenced by the emotions we are experiencing at any given moment. While humans are innately driven by their own emotions, empathy can provide enormous help to navigate the social world for better. Therefore, the study of how trait empathy and emotion mutually interact is an ongoing area of major interest for neuroscientists and psychologists in the field, although there has been little systematic study of this topic. In this chapter, the extant literature discussed provides some evidence to suggest that these constructs may be related in many contexts. As such, the nature of the interrelationships between each subtype of trait empathy related to specific emotion are not well characterized. The research presented in this thesis aims to address this current gap in the literature by means of an empirical research method which includes self-report and psychophysiological measures to examine the association between trait empathy and emotional reactivity.

1.2 Empathy

In the field of psychology, empathy is broadly accepted as a multidimensional construct rather than unitary ability which integrate both affective and cognitive component [5][6]. According to this view, the cognitive aspect refers to one's ability to recognize and imaginatively understand someone else's internal state as their feelings, thoughts, and actions, whereas the affective aspect related to the ability to share that emotional state also known as emotional empathy. These dimensions can coexist independently; for instance, deficient cognitive empathy can simultaneously occur with high emotional empathy. Most psychologists believe that empathy plays a pivotal role to confine psychopathic behaviors in adults and maintain social connections, increasing the quality of interpersonal communication, encouraging prosocial behavior, and bridging social divides. As such, empathy has been immensely studied for past decades knowing this capacity requires an exquisite interplay of neural networks. Unsurprisingly, most existing empirical research on empathy has mainly evolved around its social context, in which human to human or human to animal interaction is nucleus, whereas the impact of empathy on individuals' perception of non-social targets has considerably received far less attention.

This study, therefore, contributed along with a modicum of non-social context empathy studies, aimed at overcoming this limit and extends our current knowledge within the field by investigating the correlates between individuals' differences in empathy ability and emotion through pictures, particularly whether and how gender differences in trait empathy, and its four subscales, are associated with the psychophysiological activity of specific emotional reaction.

It is very surprising that modern perception of empathy is nearly always attached in interpersonal context. In fact, historically, empathy has been considered mainly in non-social contexts. The term “empathy” was originally coined by a distinguished German philosopher Theodore Lipps, which was not initially involved the interpersonal context in the use of the term [11]. Empathy (translated to English by Titchener 1990) was derived from the German word ‘*Einfühlung*’ meaning ‘*feeling into*’ that was used to described esthetic cognition. According to Lipps, to be capable of understand certain esthetic aspects, individuals need to launch themselves into what they are observing, penetrating into the current feeling zone. In other words, “*Einfühlung*” is extended beyond simply observation and appreciation, but opens door to explain how a person can understand the others’ consciousness. Therefore, empathy is not exclusively dedicated only to interpersonal relationship, but also for non-social targets. In the past decades, many studies have addressed how the trait of empathy influenced an emotional response that occurs vicariously [23][10]. For non-social objects, such as music, some empirical studies proposed that trait empathy and its sub-components would affect the preference for sad music directly or indirectly. Many of us may wonder why some people enjoy listening to sad music which can be considered as negative emotion, and can experience pleasant emotion when listening to it? It was revealed that the reference for sad music was mediated by the emotional response to it, together with the influence of individual differences has played in emotional responses [10]. In addition, other studies have demonstrated that while contemplating art objects, individuals with high empathy (as opposed to low empathy) are more likely to deduce an artist's feeling from the emotional valence of the artwork and, as a result, are more likely to experience the respective emotions themselves [23]. The enhanced sensitivity to others' emotions in high-empathy people is not limited to social targets, such as faces, but also extends to mental products such as visual art.

1.2.1 Psychophysiological measures for empathy

Traditionally, empathy has been mainly studied using self-report such as Interpersonal Reactivity Index [6] and behavioral measures. Those studies undeniably have flooded the field with a wealth of knowledge. However, to further understand the underlying mechanism of how empathy influences behavior, an examination of psychophysiological methodology – focused on the connection between nervous system activity and empathy – is an essential condition that should be integrated with the researching process. Benefits coming with psychophysiological measures are not only they can offer a level of objectivity that may not present with other measures, such as self-report scales, but also implementing the weak sides of other methodological tools, that could not cover the past research approaches.

In modern psychology field, the possible psychophysiological techniques which can be utilized to study empathy are substantial. Over years, researchers have implemented some measures in studying empathy according to which part they want to record, for instance, electroencephalography and neuroimaging for the central nervous system, or heart rate and electrodermal activity for the peripheral nervous system. In this study, we wanted to acquire signals from the central nervous system, and we decided to use electroencephalogram (EEG) approach for the task. The EEG is a recording of the firing of the neurons through the placement of electrodes along the surface of the scalp. The EEG produces different brain wave patterns depending on the state of the individual. Additionally, short-term changes in the EEG can be elicited by stimulus events, and these are termed event-related potentials (ERPs). Event-related potentials are an objective noninvasive approach for studying information processing and cognitive functions in the brain. Many previous studies have successfully implemented EEG and ERPs in their research on empathy, in many contexts. Late explored components, such as the P300 component, has been widely applied to assess cognitive function in previous empathy studies. For example, Hao Yu and Weizhi Nan conducted a gambling experiment analyzing the P300 and other components as important evidence to provide better understanding of how empathy towards in-group individuals can enhance attention, and competitive motivation toward out-group individuals [27]. According to this gambling experiment, opponent's loss evoked smaller P300 activity than the partner's loss condition, and there was a win versus loss difference in P300 effect for the opponent only. Moreover, the perspective-taking component may induce greater monitoring to opponent's performance, which enhances the win versus loss differentiation brain responses to the out-group agent. Another EEG study by Maffei and colleagues investigated the neural reactivity induced by movies with positive and negative emotional contents in two groups of women characterized by low and high levels of empathy. Their findings reveal that participants with high (compared to low) trait empathy exhibited an increased arousal level to all emotional stimuli, including positive, negative, and neutral movie clips [13]. Undoubtedly, using EEG and ERPs method can contribute a lot to our understanding of empathy. Therefore, in this study, we wanted to examine correlations between ERPs and self-report ratings of emotion and empathy to take a further step in understanding the association between empathy and emotion.

1.3 Emotion

The present study examines whether emotion-evocative stimuli are associated with trait empathy, how participants' emotional responses are structured, and whether such responses are correlated with empathy dimensions. Throughout our review, we concentrate on studies from a dimensional emotion perspective. According to this perspective, emotional responses are constructed based on a few fundamental dimensions. The three commonly assumed dimensions are valence, arousal, and approach-avoidance [7][8][18][20][25]. These elements can occur concurrently without affecting one another. The valence dimensions reflect states of pleasure and states of displeasure, and the arousal dimension contrasts states of low arousal with states of high arousal [3]. Approach-avoidance is a tendency of whether objects approach or avoid stimuli when different facilitated elements, such as anxiety or excitement, playing in their decisions. Throughout our review, we acknowledged that besides dimensional perspective, emotions can also be viewed from discrete perspective which contends that each emotion corresponds to a unique profile in experience, physiology, and behavior. The dimensional and discrete perspectives are not totally parallel from each other but can reconcile each other to some extent. For example, erotic could be characterized by positive valence, high arousal, and approach motivation, whereas fear could be characterized by negative valence, high arousal, and avoidance motivation. However, these two perspectives still differ in the way they conceptualize the emotional states. For this reason, we only choose to measure emotional responses from the dimension perspective to establish correlations with traits of empathy. Understanding emotional measurements should be operated under subjective and objective stand points, we will discuss our choice whether it is a self-report or physiological approach in measuring emotion.

1.3.1 Self-report measure of emotion

Self-reports are commonly used in psychological studies because they can yield much valuable and diagnostic information to a researcher. One of the primary advantages of self-report is that its data can be easy to obtain. It is inexpensive and can reach many more subjects than other methods. Considering self-reports of emotion being able to retain these benefits, the validity of these reports needs to be carefully considered in the time span. For instance, self-reports of current emotional experiences are likely to be more valid than are self-reports of emotion made somewhat distant in time from the relevant experience. As we will describe the experiment in the next chapter, we asked the participants fulfilled the self-report of emotion following after each stimulus presented.

In the domain of self-reported emotional states, it is quite clear that dimensions such as valence and arousal or approach/avoidance tendency are autonomous, as differing values along any these three dimensions can occur concurrently without affecting one another. The three-dimensional model allows people to describe their experiences in terms of more “basic, concrete” emotions as well as in the more abstract dimensions. To make this model functional, the Self-Assessment Manikin (SAM) [3] is one of the promising solutions to other sometimes-cumbersome verbal self-report measures. There are many reasons we thought SAM would be a great choice as a self-affective rating assessment. Firstly, participants can complete ratings on the SAM scales in less than 15 minutes, allowing a sequence of stimuli to be tested in a short amount of time, and causing less respondent fatigue than the verbal measures. Secondly, past experiences have showed that participants have had greater interest in SAM ratings versus verbal self-reports. And a third advantage of SAM is that different population of subjects, including both children and adults, readily identify with SAM figure and easily understand the emotional dimensions it represents. In addition, SAM is versatile because no culture or language barrier exists in the report. This measurement is suitable for use in different countries and cultures.

1.3.2 Gender differences during emotional processing

Many studies have reported difference between women and men in their psychological and physiological responses to wide range of emotional stimuli [14] [4]. For example, women have been reported to respond more expressively than men to emotional stimuli, to report feeling more emotion, and to display heightened physiological arousal responses. However, the empirical literature remains somewhat inconsistent regarding the nature of gender differences in responses to stimuli, and the magnitude of observed gender differences has varied widely across the studies. The study of gender differences corresponding to negative emotions have been demonstrated more consistently than to positive emotions. There is currently little evidence to suggest the existence of gender differences in responses to positive stimuli in general, and this limited evidence suggests that men are more emotionally aroused by erotic visual stimuli, showing higher subjective ratings of affect and greater skin conductance responses [4].

CHAPTER 2: THE RESEARCH

In the first chapter, we have discussed background literature relevant to the present study. We provided a broad overview of trait empathy and emotion, and how individual differences could affect the relationship between these two constructs. Moreover, we also discussed the effect of the gender in the behavioral and electrophysiological responses to emotional stimuli. To fully capture the idea of how empathy traits and emotion interacting with each other, we carried out an experiment which incorporate both self-report and psychophysiological measures for empathy and emotion. In this chapter, we will describe the entire experiment process and the results to clarify whether empathy traits and gender of participants could modulate the brain responses induced by different emotional stimulation.

Through this study, we want to discuss an empirical work that can provide some insight into the potential nature of the association between empathy, gender and emotion. We aimed to address whether and how trait empathy, and its sub-components, would reflect in the participants' affective and physiological responses to pleasant and unpleasant stimuli. Many available literatures have suggested that individuals with high level of empathy tends to have greater sensitivity and emotional activation to stimuli regardless of their categories ranging from negative to positive. Within this general tendency, we want to specifically examine the effect of trait empathy on affective cortical activity. Regarding trait empathy self-rating report, we used the Interpersonal Reactivity Index (IRI) which comprises four subscales as Empathic Concern (EC), Personal Distress (PD), Perspective Taking (PT), and Fantasy (FS) [5]. We used various pictures as stimuli varying from positive (Erotic, Sport) to negative (Threat, Mutilation) contents, selected from reliable and validated source, that successfully proved to be capable of stimulate observers' emotional state. These pictures were intendedly used to trigger arousal state with opposite valence dimension. Thus, among the four subscales of the IRI [Empathic Concern (EC), Personal Distress (PD), Perspective Taking (PT), and Fantasy (FS)], we expected to identify whether a specific subcomponent of empathy is correlated with psychophysiological responses to emotional stimuli.

We also sought to investigate the potential impact of gender differences in trait empathy on arousal elicited by affective stimuli. The current findings highlighted the importance of gender as a potential factor which can modulate emotional processing and its underlying neural mechanism, and more broadly, the importance to take individual differences in consideration to understand the neurobiology of emotion. With a purpose of overcoming this limit, we included in our experimental design both negative and positive emotional stimuli, to have better insight in emotional responses between male and female groups.

In summary, there is evidence of a correlation between trait empathy and emotional responses. Overall, a limited number of studies investigated the emotional processing taking into consideration the impact of both empathy traits and gender of the participants. The present study provided a contribution to further studying the brain responsiveness to emotional stimuli using a paradigm that combined behavioral with electrophysiological indices.

2.1 Participants

An initial sample group of 215 subjects completed the IRI and undergoing an online screening of age, educational levels, history of neuropsychological disorders, history of drug use and empathy and fear inventory to favor eventual 40 suitable subjects matched for age, education and IRI scores which evenly divided into 2 subgroups of 20 males and 20 females for further stage of the study (20 women, mean age: 22.45 ± 2.91 years; 20 men, mean age: 22.40 ± 2.41 years; t(38) = 1.24, *n.s.*). The trait empath self-report IRI comprises four subscales as Empathic Concern (EC), Personal Distress (PD), Perspective Taking (PT), and Fantasy (FS). The selected participants continue taking part in the next phase of the experiment, which included the collection of their EEG brain activity during the resting stage as well as the passive view of emotional photographs. The present study, which was approved by the Ethics Committee of the Department of general Psychology, committed to adhere the principles expressed in the Declaration of Helsinki. The participants provided their written informed consent to participate in this study.

2.2 Stimuli

Before starting the experiment, all participants were asked to complete two additional questionnaires: The STAI Y and the PANAS. The State-Trait anxiety Inventory (STAI) [21] is a psychological inventory consisting of 40 self-report items on a 4-point Likert scale. It measures two types of anxiety – state anxiety and trait anxiety. Participants who had higher scores are positively correlated with higher levels of anxiety. Meanwhile, the Positive and negative Affect schedule (PANAS) [26] is a scale that consists of different words that describe feelings and emotions. Participants gauge their feelings and respond via a questionnaire with 20 items. A 5-point Likert scale is used for scoring. The PANAS measures both positive and negative emotions. The positive affectivity refers to positive emotion and expressions such as joy and cheerfulness, while negative affectivity refers to negative emotions and expressions such as anger and fear.

Participants were presented with 130 images (average duration = 2 seconds) corresponding to five different categories (26 images for each category). The images have been tested and proven to be effective in provoking emotional responses and are part of the International Affective Pictures System (IAPS) [2]. Erotic and extreme sport images were selected to induce a positive emotional state as opposed to a negative emotional response, which was induced by fear and mutilation images. Neutral images were also presented as control condition. Regarding positive emotional stimuli, erotic picture which portraying heterosexual couples engaged in sexual intercourse was expectedly characterized by high arousal and high positive arousal responses, that were also expected for pictures (for example) of a human hanging on the cliff in the extreme sport images. On the other hand, we selected fear images, which included attacking scene of dangerous animals to induce a negative emotional state, characterized by a withdrawing motivation, and mutilation pictures in which one could see, for example, a depicting scene of skinless human body, to elicit in the viewer a high negatively arousal effect, characterized by an empathic reaction toward others' physical sufferance. Finally, a neutral stimulus condition comprised objects commonly used in everyday life activities. The participants were passively viewed with pseudo-randomized to avoid consecutive presentation of two pictures belonging to the same category.

2.3 Procedure

Before starting the experiment, every participant received a description of the experimental design. To start the session, participants were asked to sit comfortably in a chair and the EEG montage was prepared. The signal acquisition session comprised two main phases. For the first five minutes, the participants were recorded during a resting state phase (eyes open) without seeing anything. Then moving onto the second phase of the procedure, in which a single image was presented on a computer screen, to acquire the EEG signals (considered for the analysis) from the participants during the stimuli presentation (passive viewing emotional task).

2.4 SAM as self-report of affective experience

At the end of EEG experiment, participants needed to subjectively assess their affection by fulfill the Self-Assessment Manikin (SAM) report. SAM was designed as an alternative to many unnecessarily verbal self-report measure [3]. SAM depicts each affective dimension with a graphic character arrayed along a continuous nine-point scale (Figure 1).

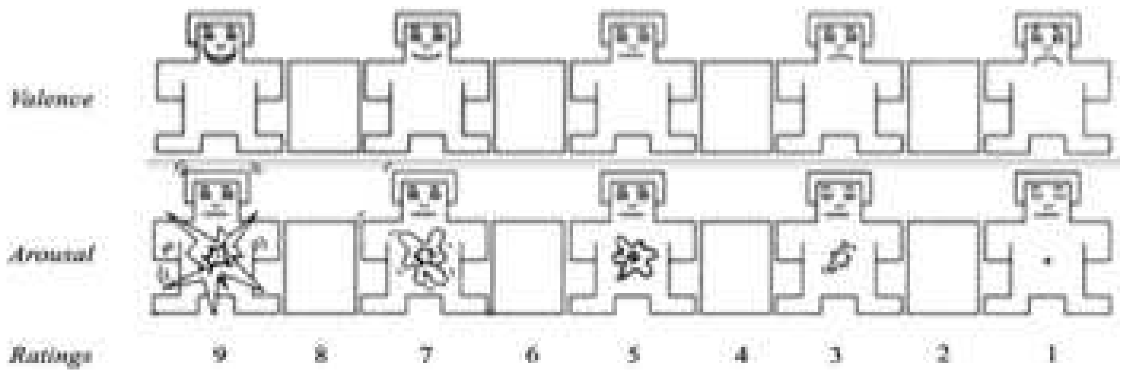

Figure 1. Schematic representation of the Self-Assessment Manikin (SAM) (Source [3]).

For instance, to judge perceived valence, SAM presents from a smiling, happy figure to a frowning, unhappy figure (9 extremely pleasant – 1 extremely unpleasant); for perceived arousal, SAM ranges from sleepy with eyes closed to excited with eyes open. Due to its high validity and reliability, SAM has been used in numerous psychophysiological studies since its development.

2.5 EEG recording and data reduction

We recorded EEG activity by using an elastic cap with 64 electrodes (Activecap, BrainProduct System) according the 10-20 International System.

2.5.1 EEG signal preprocessing and analyses

The EEG data obtained through the resting state and the experiment were offline preprocessed before being split into epochs considered for analysis. This preprocessing procedure focused mainly on interpolating bad channels, re-referencing to average reference, and reconstructing FCz reference (BrainVision Analyzed software). We chose Brainstorm software to perform the artifact removing procedure. This process started with creating new protocols and new subjects. When the EEG data was imported, the specific EEG montage was selected for ensuring the correct position of each channel in the head. Next, we moved onto setting band-pass filter for the data (0.5-125 Hz) and removed possible eye movement artifacts such as blinks, horizontal and vertical movement through the ICA component visualization process. Once the selection of ICs was completed, EEG data was divided in epochs of -500 and 2000 milliseconds (ms) before and after the stimulus onset. Baseline correction (-100/0 ms) was thus computed on each epoch. Epochs with residual noise were deleted first by using a peak-to-peak procedure (threshold value = ± 100 μV) that rejected the entire epoch, and lastly by visually inspecting the residual artifact-free epochs.

P1 and P300 components were analyzed. The time window the P1 component corresponded to the 110-130 ms interval after stimulus onset. P300 component included the 200-340 ms temporal window after stimulus onset. Two clusters of channels were created including 5 parieto-occipital channels in left hemisphere (P7-P5-PO7-PO3-O1) and 5 parieto-occipital channels in the right hemisphere (P8-P6-PO8- PO4-O2). ERP data was thus analyzed by means of ANOVA (2 gender [males *vs.* females] x 5 stimuli [sport *vs.* erotic *vs.* neutral *vs.* mutilation *vs.* fear images] x 2 laterality [left *vs.* right hemisphere sites]).

Finally, to investigate the gender and empathy effects on emotional processing, correlations were computed between the source data analysis in the same temporal windows corresponding to P1 and P300 components, and the IRI scores of the two groups, considering the 5 emotional categories. The source analysis was computed using the standardized low resolution brain electromagnetic tomography (sLORETA) method [18]. Since sLORETA computes the smoothest possible 3D-distributed current source density solution constrained to grey matter, this approach was particularly suited for our analysis since, due to the smoothness constraint, it does not need an a priori definition of known sources. Pearson's correlation (5000 permutations) were carried out separate for women's and men's P1 and P300 components elicited by erotic and mutilation images only (as these two stimulus categories showed both subjective and ERP significant modulations) and the IRI (total and subscale) scores. All results are expressed in MNI coordinates.

2.5.2 Behavioral analysis

Valence and arousal data were analyzed by means of two separate ANOVAs (2 gender [males *vs.* females] x 5 stimuli [sport *vs.* erotic *vs.* neutral *vs.* mutilation *vs.* fear images]. Data analyses were performed using the Statistica 6.1 (StatSoft GmbH) software. Post-hoc comparisons were computed using the Newman-Keuls method ($p < 0.05$), and the Greenhouse-Geisser correction was applied when necessary (df > 2).

2.6 Results

2.6.1 SAM ratings

The ANOVA carried out on the valence scores showed both main effects of gender ($F_{1,38}$ = 6.25, p = 0.017) and stimulus category ($F_{4,152}$ = 225.77, HF ε = 0.78, p <0.001). The main effect of gender revealed that men, in general, expressed higher valence scores than women (4.57 *vs.* 4.10, respectively). On the other hand, the stimulus main effect revealed highest scores for positive emotional stimuli (sport = 6.26, erotic = 6.62) and lowest scores for negative stimulus categories (mutilation = 1.68, fear = 2.66), with neutral stimuli rated in the middle of the valence spectrum (4.47). Additionally, a significant 2-way interaction emerged (Figure 2), between Gender and Stimulus ($F_{4,125}$ = 3.57, HF ε = 0.78, p = 0.01).

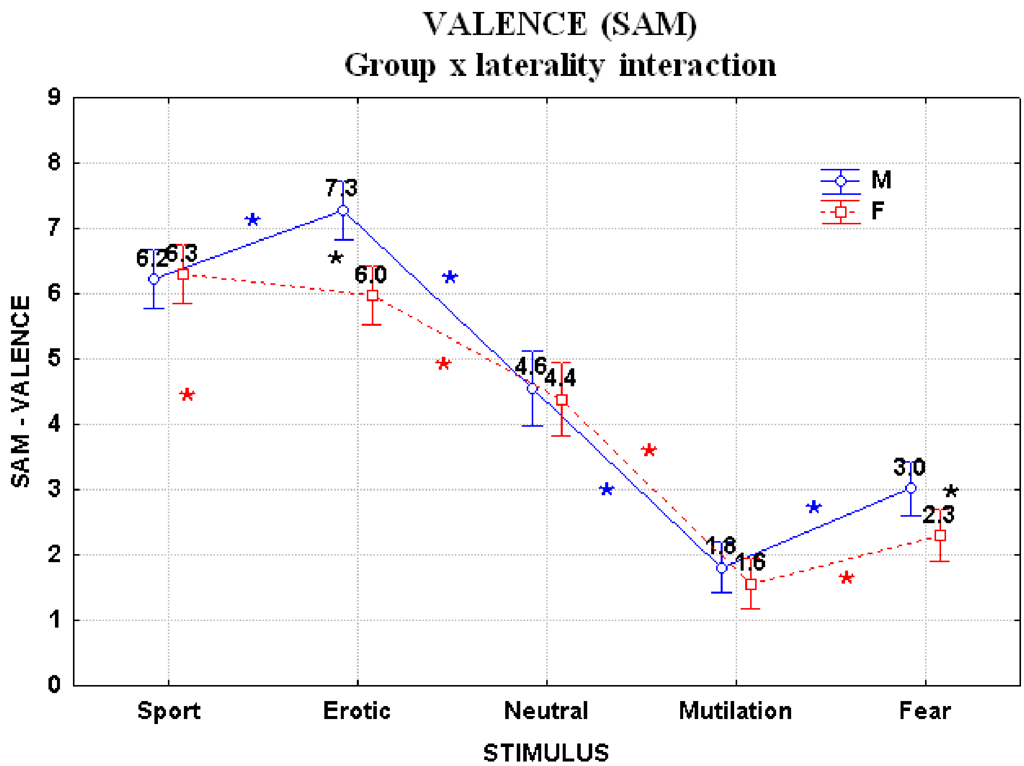

Figure 2. Gender x stimulus interaction for valence (SAM).

Both groups exhibited the stimulus main effect above-mentioned. In addition, men reported significant higher valence ratings for erotic and fear pictured, compared with women ($p < 0.001$ and $p < 0.05$, respectively).

The ANOVA carried out on arousal scores revealed the stimulus main effect ($F_{4,152}$ = 101.63, HF ε = 0.84, $p < 0.001$) and a significant 2-way interaction between Gender and Stimulus ($F_{4,152}$ = 5.71, HF ε = 0.84, $p < 0.001$)). The stimulus main effect showed that emotional stimuli induced higher arousal compared to the neutral ones (Sport = 3.89 Erotic = 5.06, Mutilation = 5.73, Threatening = 4.50 and Neutral = 1.47; all ps < 0.01). As show in the Figure 3, females referred subjective lower arousal than men when viewing erotic images, but significantly higher arousal scores than men during presentation of mutilation pictures ($p < 0.05$ and $p < 0.001$, respectively).

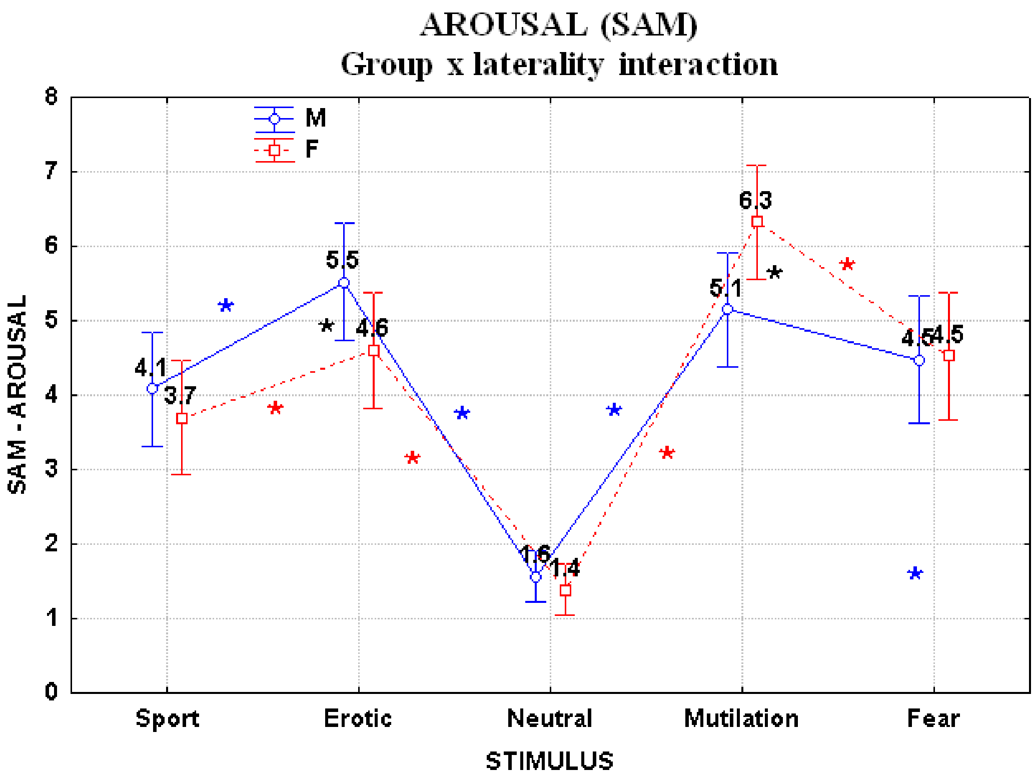

Figure 3: Gender x stimulus interaction for arousal (SAM).

There were no significant differences in the arousal scores between males and females for all other stimuli.

2.6.2 P1 component

A repeated measures ANOVA was conducted on the P1 component. A stimulus main effect ($F_{4,152} = 4.20$, HF $\varepsilon = 0.95$, $p < 0.01$) emerged showing significant differences between erotic *vs.* sport ($p = 0.05$) and between erotic *vs.* neutral ($p < 0.05$), with erotic stimuli having an overall high P1 amplitude. Moreover, regardless of the gender, the P1 amplitude was higher for mutilation than neutral images ($p < 0.05$). No differences between fear and all the other stimuli emerged. Results also showed a 2-way interaction between Group and Hemisphers ($F_{1,38} = 7.44$, $p < 0.01$), revealing that the P1 amplitude in the right hemisphere was significantly greater for females than males ($p = 0.002$; Figure 4).

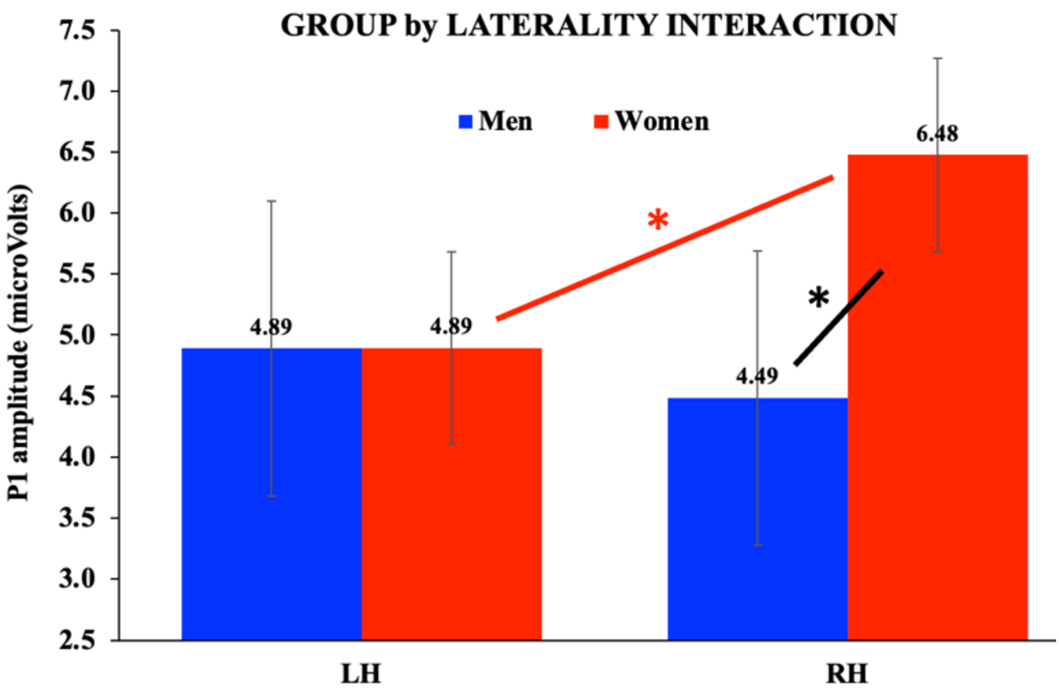

Figure 5: Gender x hemisphere interaction for the P1 component.

For females only, greater P1 was lateralized, showing greater amplitude in the right *vs.* left cluster (p = 0.019). No differences emerged for the male group between left and right hemisphere.

Correlations between source analysis carried out in the P1 component temporal window (110-130 ms after stimulus onset) associated with erotic and mutilation image processing and empathy traits was performed using the sLORETA software for comparing male and female responses during the processing of different emotional information. A significant negative correlation (r = -0.82, p = 0.040) emerged between Perspective Taking (PT) scores from IRI questionnaire and P1 source during the mutilation picture processing in men (Figure 6).

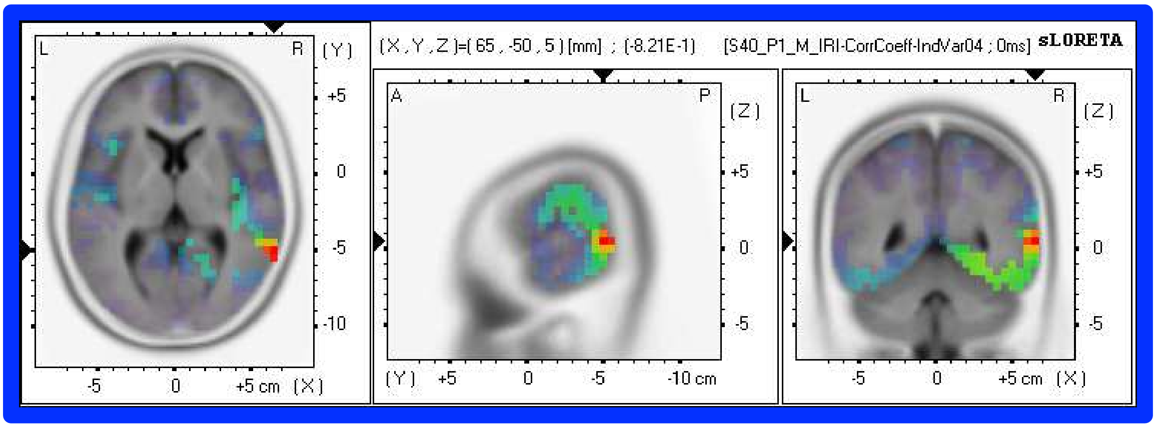

Figure 6. Significant negative correlation between the perspective taking (PT) IRI subscale and the P1 neural correlate active during men's mutilation picture processing.

This negative correlation was found in the right superior/middle Temporal Gyrus (BA 21-22; MNI coordinates X = 65, Y = -50, Z = 5): the higher the PT scores, the lower the activity of this region in the 110-130 ms temporal window.

Furthermore, we detected a significant positive correlation (r = 0.77, p = 0.049) between P1 source and the Personal Distress (PD) scores when male participants were watching erotic picture (Figure 7).

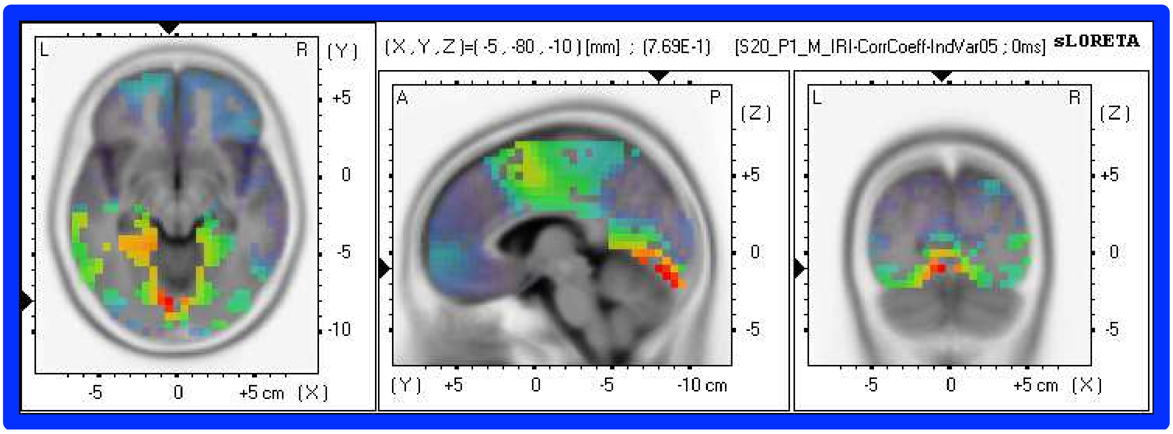

Figure 7. Significant positive correlation between the personal distress (PD) IRI subscale and the P1 neural correlate active during men's erotic picture processing in men.

The region in which this effect emerged was the Lingual Gyrus region (BA 18; MNI coordinates X = -5, Y = -80, Z = -10). In other words, the higher PD scores male participants had, the greater they activated P1 signal in this region, in the 110-130 ms temporal window during the erotic image processing.

Source analysis on female group showed a significant negative correlation (r = -0.74, p = 0.049) between the left Supramarginal gyrus (BA 40; MNI coordinates X = -50, Y = -35, Z = 50) and the level of trait empathy (IRI total score) when female participants watched mutilation image (Figure 8).

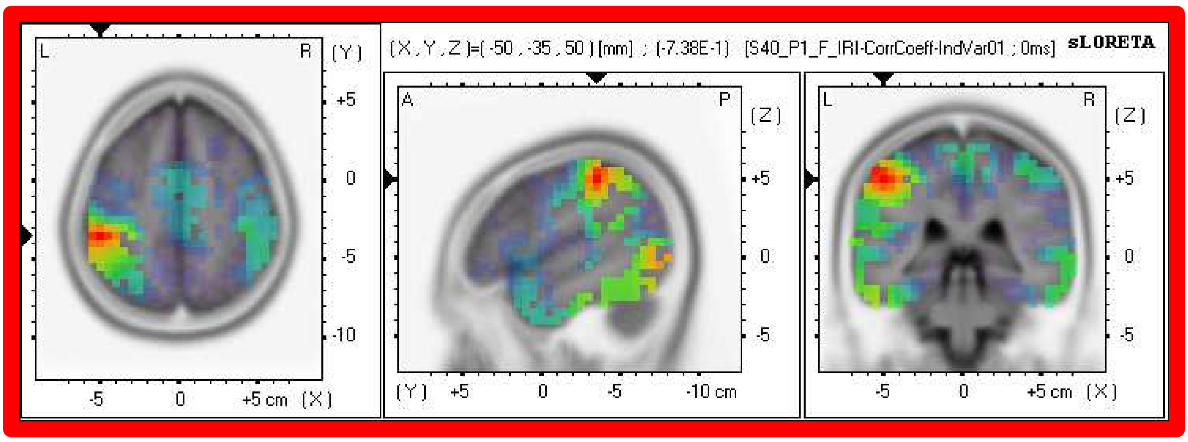

Figure 8. Significant negative correlation between the IRI total scores and the P1 neural correlate active during women's mutilation picture processing.

Female participants with higher empathy scores would have lower cortical activity (110-130 ms temporal window) in the left Supramarginal gyrus. In addition, the right Superior temporal gyrus (BA 22; MNI coordinates X=45, Y = -20, Z =-5) was negatively associated with the IRI total scores during erotic picture processing (Figure 9).

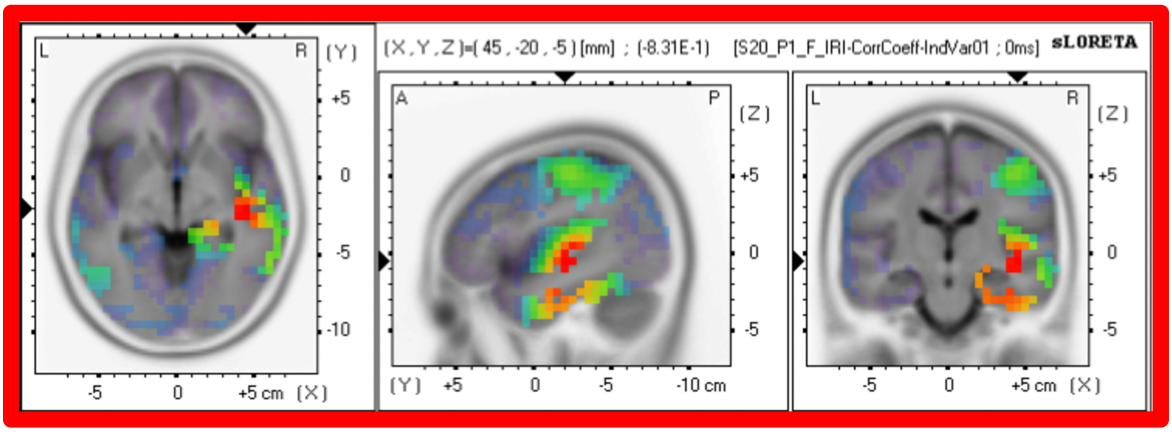

Figure 9. Significant negative correlation between the IRI total scores and the P1 neural correlate active during women's erotic picture processing.

The higher the IRI total scores, the lower the activity in this region in the 110-130 ms temporal window during the erotic picture processing in women.

2.6.3 P300 component

The ANOVA carried out on the P300 component (200-340 ms after stimulus onset) revealed the significant main effects of stimulus category ($F_{4,152} = 43.76$, HF $\varepsilon = 0.98$, $p < 0.001$) and laterality ($F_{1,38} = 12.59$, $p = 0.001$). Post-hoc contrasts on the Stimulus category showed that sport images elicited the largest P300 amplitude compared to the rest of the pictures (all ps < 0.001), whereas P300 amplitudes for erotic picture were lower compared to all other stimuli (all ps < 0.001) (Figure 10). Regarding the hemisphere main effect, regardless of participants' gender, the amplitude of P300 component was greater in right sites (M = 10.45, SE = ± 1.57 µV) than left homologues (M = 9.4 ± 1.48 µV).

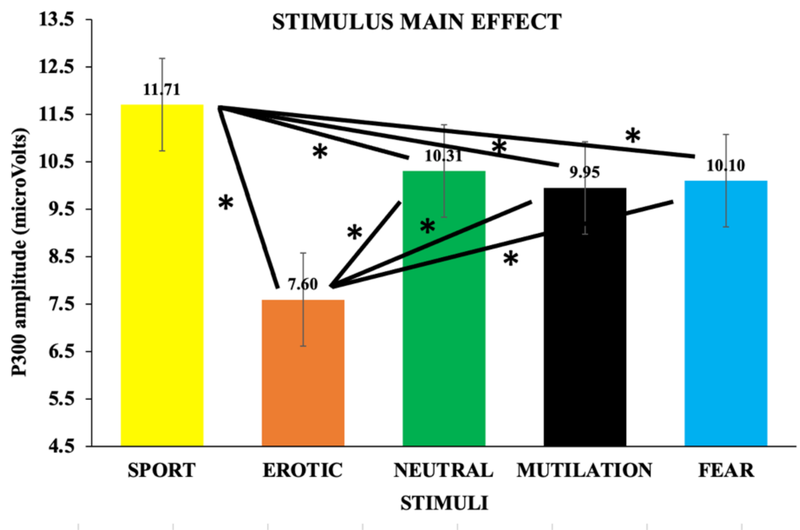

Figure 10. Stimulus main effect for the P300 component.

sLORETA analysis identified significant correlations with empathy in the female group only. In particular, the source analysis carried out in the P300 temporal window (200-340 ms after stimulus onset) revealed that female right inferior parietal lobule (BA 40; MNI coordinates X= 45, Y= -35, Z= 45) was the cortical region which showed the strongest positive correlation (r = 0.81, p = 0.014) with the Fantasy (FS) scores during the presentation of erotic images (Figure 11).

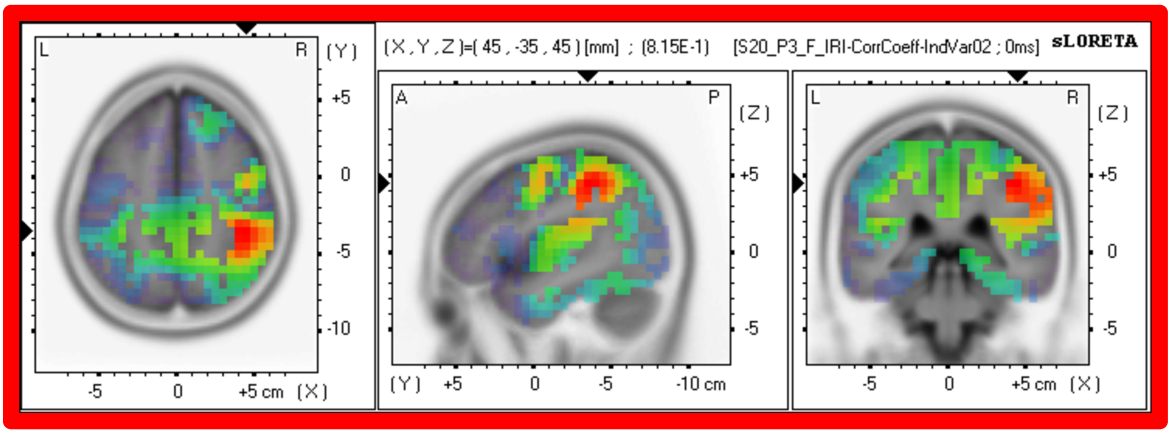

Figure 11. Significant positive correlation between the fantasi scale (FS) IRI subscale and the P00 neural correlate active during women's erotic picture processing.

In other words, the higher the women's FS scores, the greater their activity in this region, in the 200-340 ms temporal window, only during the processing of erotic pictures.

3. DISCUSSION AND CONCLUSIONS

The main objective of the present study was to examine that whether and how gender differences in trait empathy and its sub-components would have different connections with specific emotional contents (e.g., positive, negative, or neutral images). A previous investigation suggested that high empathy women showed greater responses to all emotional film clips compared to the neutral ones [13], but, so far, no study investigated this association with emotional, yet non-social, context stimuli in both genders, instead of only women. The main hypothesis of this study stated that there would be a correlation between specific subscales of empathic traits and psychophysiological responses (specifically focusing on P1 and P300 components) to emotional images.

The self-rating report analysis showed main findings in behavioral responses. The analysis of valence ratings revealed a main gender effect, as men reported an overall higher valence with respect to women, therefore they perceived all emotional stimuli as more pleasant. In addition, it also revealed a main effect of emotional stimulus independent from the group. This result confirmed that positive stimuli (extreme sports and erotic images) were rated as more pleasant, and negative stimuli (mutilation and fear pictures) as more unpleasant, compared to the neutral images. The gender and stimulus factor had a significant interaction with each other. Regarding to a specific type of pictures, only erotic and fear stimuli have induced a significant difference in the valence continuum between men and women. As we mention above, those men felt better pleasant than women did, which made sense in both erotic and mutilation case where men reported a significantly higher valence scores than women. Instead, the analysis of arousal levels showed that men were more aroused to erotic images (positive emotion) as opposite to women who reported greater arousal scores for mutilation pictures (negative emotion).

These findings about gender differences in valence and arousal were consolidated with a result of a previous study carried out by Deng and Zhou about gender differences in emotional responses. This study asserted that in the similar emotion triggering context, women have higher emotional expressivity in which they often reported higher levels arousal and lower valence than men [8].

Concerning the analysis conducted to investigate the cortical dynamics underlying emotional stimulus processing, we selected P1 and P300 component as a measure of brain activation during the early processing phases of emotional information. Two main results were obtained in P1 and P300 components. First, in the P1 time interval (110-130 ms), erotic and mutilation pictures induced an overall greater amplitude compared to the neutral ones. In particular, the P1 amplitude in the right hemisphere was significantly greater for females than males, and for females only significant right hemisphere dominance was found. We know that the P1 is a positive ERP component depending on the neural activity of the extrastriate area in the visual cortex. There are many findings that have overall found out gender differences in visual areas. For instance, a study by Malcolm and colleagues revealed that the P1 component of the visual-evoked potential was considerably reduced in female than male infants [12]. Another research found that, responding to moving-visual stimuli, central field stimulation induced a larger event-related potentials in right than left hemisphere in females only [1]. From the self-rating affective report analysis, we knew that women, compared with men, perceived all affective visual images as less pleasant, and reported increased self-perceived levels of arousal specifically for unpleasant image (i.e., mutilation) category. Smith et al. [15] showed that, in an emotional task, the amplitude of the P1 was greater for the unpleasant arousing stimulation than for the pleasant arousing ones. We can interpret this result as an index of negativity bias in attention allocation in the extrastriate visual cortex, with higher resources devoted to unpleasant stimuli.

Focusing on the associations with empathic traits, men's perspective taking (PT) scores showed a negative correlation with the right superior/middle temporal gyrus region in the P1 temporal window: those individuals who scored higher in PT subscale scores would have lower activity in the right superior/middle temporal gyrus region during the mutilation picture processing. In the IRI questionnaire, the perspective taking scale measures the reported tendency to spontaneously take over the psychological point of view of others [5][6]. In other words, people try to understand the others better by imaging how things look from their perspective. In this view, superior/middle temporal regions are involved in higher level visual emotional processing [16]

In addition, men have another positive correlation between higher personal distress (PD) scores and greater activation in the Lingual Gyrus region while watching erotic pictures (again in the P1 temporal window). The personal distress (PD) scale measures the tendency to experience distress and discomfort in response to extreme distress in others. This results might related to lower inhibition was associated with larger gray matter volume (GMV) in the lingual gyrus, which in turn was associated with higher divergent thinking. The GMV in the lingual gyrus typically mediates the association between inhibition and divergent thinking [28]. Women did not show any correlations of brain activation with a specific empathy subscale, but rather with total IRI scores. Indeed, their IRI scores were negatively correlated with the left Supramarginal gyrus, during the mutilation picture processing, and with the right superior temporal gyrus, while watching the erotic pictures. These findings suggested that, regardless of the valence, highly arousing and biologically relevant stimuli, such as erotic and mutilation images, elicited lower activation in superior temporal gyrus and supramarginal gyrus of right and left hemisphere, respectively, in the temporal window corresponding to the P1 component in high-empathy women. A previous study carried out by Maffei and collaborators showed a similar phenomenon considering EEG gamma activity. This work mentioned the fact that valence – i.e., pleasantness or unpleasantness – does not contribute to increased responses to all emotional clips of women with high trait empathy. However, the authors did not find a pure arousal effect at cortical level: EEG gamma activity during erotic movie processing was lower with respect to that found for negative clips [13].

Considering the late ERP components, extreme sport images elicited the greatest P300 amplitude, whereas erotic pictures the lowest. The P300 component were overall dominant in the right hemisphere. This is one of ERP component to assess the neural underpinnings of cognition, and the attentional resources in particular. Among all stimuli, extreme sport pictures might be the ones that induced the most cognitive appraisal based on past experience and knowledge from the participants. Therefore, it was not surprising that this kind of stimuli elicited the highest P300 amplitude among stimuli. We did not found correlations in the P300 window source analysis for men, but only for women, who exhibited a positive correlation between the fantasy scale IRI subscale and the right inferior parietal lobule activation while watching erotic pictures. The fantasy scale measures the tendency to imaginatively transpose oneself into fictional situations. In the past, men often referred more sexual fantasies than women. However, the gender differences in this matter have narrowed down. A recent replication study on this tendency by Hsu and Kling unveiled an opposite trend, as there is a greater correlation between sexual fantasies and experiences in women than in men [9]. In addition, regarding gender differences in brain structure, women show wider gray matter volumes than men in the pars opercularis and inferior parietal lobule of the right hemisphere. The gray matter volume in these areas showed a positively correlation with the EETS (Emotional Empathic Tendency scale) across all genders [28].

Taken together, these results give us new insights about the role of empathy and its subscales combined with gender differences in modulating emotional reactivity at both behavioral and cortical level, showing that gender differences – particularly in the empathy dimensions and generally in the ability to empathize – can intervene in how people would respond to emotional stimuli, in a non-social setting. Spefically, the ERPs results revealed that the brain regions that interacted with empathy are only active in response to specific cues of disparity in gender dispositions and emotional sufferance (mutilation) and excitement (erotic) in others, and this activation covaries with the participants' subjective scores of trait empathy. We successfully took advantage of diversity in stimuli category ranging from positive and negative and differences in gender to detect the intercorrelations among gender to trait empathy, trait empathy to emotional responses, and gender to emotional response. It was very clear that, at subjective level self-rating report, despite many gaps in comparison, women and men showed very similar emotional response tendencies to all stimuli.

For better future improvement, we acknowledge that our study still has some limitations. First, we only used one measure, the IRI questionnaire, to assess empathy behavior evaluation. Besides IRI report, it is possible to use other measurements, such as EETS, especially considering the emotional context to evaluate empathy complex construct, which might lead to different findings. Furthermore, in the participant population, as we tried to balance with the presence of both males and females, the whole group was still selected from one specific culture and same educational background. Future studies could therefore consider to extend the present findings by testing participants from different culture, ranging from the East to the West, assuming the East culture is the collective culture, and the West is the individualistic culture, as this aspect might affect on how people differently perceive emotional stimuli. And finally, it is important to mention that we only utilized EEG technique for the investigation. Future studies could collect also peripheral nervous indices, such as skin conductance and heart rate, and complementing the central nervous recordings with neuroimaging measures, such as PET or fMRI.

References

[1] Andreassi JL, Juszczak NM (1982) Hemispheric sex differences in response to moving stimuli as indicated by visual evoked potentials. Int J Neurosci 17:83–91.

[2] Bradley, M. M. & Lang, P. J. (2007). The International Affective Picture System (IAPS) in the study of emotion and attention. In J. A. Coan and J. J. B. Allen (Eds.), Handbook of Emotion Elicitation and Assessment (pp. 29-46). Oxford University Press

[3] Bradley, M. M., and Lang, P. J. (1994). Measuring emotion: the self-assessment manikin and the semantic differential. J. Behav. Ther. Exp. Psychiatry 25, 49–59. doi: 10.1016/0005-7916(94)90063-9

[4] Cheng Y, Chou KH, Decety J, Chen IY, Hung D, Tzeng OJ, Lin CP. Sex differences in the neuroanatomy of human mirror-neuron system: a voxel-based morphometric investigation. Neuroscience. 2009 Jan 23;158(2):713-20. doi: 10.1016/j.neuroscience.2008.10.026. Epub 2008 Nov 1. PMID: 19010397.

[5] Davis, M. H. (1980). A multidimensional approach to individual differences in empathy. JSAS Catalog of Selected Documents in Psychology, 10, 85.

[6] Davis, M. H. (1983). Measuring individual differences in empathy: Evidence for a multidimensional approach. Journal of Personality and Social Psychology, 44, 113-126.

[7] Davidson RJ. Neuropsychological perspectives on affective styles and their cognitive consequences. In: Dalgleish T, Power MJ, editors. Handbook of cognition and emotion. New York: Wiley; 1999. pp. 103–123.

[8] Deng, Y., Chang, L., Yang, M., Huo, M., & Zhou, R. (2016). Gender Differences in Emotional Response: Inconsistency between Experience and Expressivity. PloS one, 11(6), e0158666.

[9] Hsu B, Kling A, Kessler C, Knapke K, Diefenbach P, Elias JE. Gender differences in sexual fantasy and behavior in a college population: a ten-year replication. J Sex Marital Ther. 1994 Summer;20(2):103-18. doi: 10.1080/00926239408403421. PMID: 8035467.

[10] Kawakami, A., & Katahira, K. (2015). Influence of trait empathy on the emotion evoked by sad music and on the preference for it. Frontiers in Psychology, 6(OCT), [1541].

[11] Lipps, T. (1903). Empathy, inner imitation, and sense-feelings. Archiv fuer die gesamte Psychologie, 1, 291–304.

[12] Malcolm CA, McCulloch DL, Shepherd AJ (2002) Pattern-reversal visual

evoked potentials in infants: gender differences during early visual maturation. Dev Med Child Neurol 44:345–351.

[13] Maffei A, Spironelli C, Angrilli A. Affective and cortical EEG gamma responses to emotional movies in women with high vs low traits of empathy. Neuropsychologia. 2019 Oct;133:107175. doi: 10.1016/j.neuropsychologia.2019.107175. Epub 2019 Aug 24. PMID: 31449821.

[14] McRae, Kateri et al. “Gender Differences in Emotion Regulation: An fMRI Study of Cognitive Reappraisal.” Group processes & intergroup relations : GPIR vol. 11,2 (2008): 143-162. doi:10.1177/1368430207088035

[15] N.K. Smith, J.T. Cacioppo, J.T. Larsen, T.L. Chartrand. May I have your attention, please: Electrocortical responses to positive and negative stimuli. Neuropsychologia, 41 (2003), pp. 171-183

[16] Pourtois, G; Degelder, B; Bol, A; Crommelinck, M (2005). "Perception of Facial Expressions and Voices and of their Combination in the Human Brain". Cortex. 41 (1): 49–59

[17] Pascual-Marqui RD. Standardized low-resolution brain electromagnetic tomography (sLORETA): technical details. Methods Find Exp Clin Pharmacol. 2002;24 Suppl D:5-12. PMID: 12575463.

[18] Russell JA, Barrett LF. Core affect, prototypical emotional episodes, and other things called emotion: Dissecting the elephant. Journal of Personality and Social Psychology. 1999;76(5):805–819.

[19] Salti M, Bar-Haim Y, Lamy D. The P3 component of the ERP reflects conscious perception, not confidence. Conscious Cogn. 2012 Jun;21(2):961-8. doi: 10.1016/j.concog.2012.01.012. Epub 2012 Feb 16. PMID: 22341937.

[20] Schneirla TC. An evolutionary and developmental theory of biphasic processes underlying approach and withdrawal. In: Jones MR, editor. Nebraska symposium on motivation, 1959. Lincoln, NE: University of Nebraska Press; 1959. pp. 1–42.

[21] Spielberger, C. D., Gorsuch, R. L., Lushene, R., Vagg, P. R., and Jacobs, G. A. (1983). Manual for the State-Trait Anxiety Scale. Palo Alto, CA: Consulting Psychologists Press

[22] Stavrova O, Meckel A. Perceiving emotion in non-social targets: The effect of trait empathy on emotional contagion through art. Motiv Emot. 2017;41(4):492-509. doi: 10.1007/s11031-017-9619-5. Epub 2017 May 18. PMID: 28757668; PMCID: PMC5509827.

[23] T. Singer, C. Lamm The social neuroscience of empathy Ann. N. Y. Acad. Sci., 1156 (2009), pp. 81-96

[24] Wolpe, J., and Lang, P. J. (1964). A fear survey schedule for use in behaviour therapy. Behav. Res. Ther. 2, 27–30. doi: 10.1016/0005-7967(64)90051-8

[25] Watson D, Wiese D, Vaidya J, Tellegen A. The two general activation systems of affect: Structural findings, evolutionary considerations, and psychobiological evidence. Journal of Personality and Social Psychology. 1999;76(5):820–838.

[26] Watson, D., Clark, L. A., & Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: the PANAS scales. Journal of personality and social psychology, 54(6), 1063.

[27] Yu Hao, Nan Weizhi, Yang Guochun, Li Qi, Wu Haiyan, Liu Xun. Your Performance Is My Concern: A Perspective-Taking Competition Task Affects ERPs to Opponent’s Outcomes. Frontiers in Neuroscience. 2019 Oct

[28] Zhang L, Qiao L, Chen Q, Yang W, Xu M, Yao X, Qiu J, Yang D. Gray. Matter Volume of the Lingual Gyrus Mediates the Relationship between Inhibition Function and Divergent Thinking. Front Psychol. 2016 Oct 3;7:1532. doi: 10.3389/fpsyg.2016.01532. PMID: 27752250; PMCID: PMC5047031.