NEURAL CORRELATES OF SYMPATHY

A Senior Scholars Thesis

by

LAURA CHRISTINE GRAVENS

Submitted to the Office of Undergraduate Research
Texas A&M University
in partial fulfillment of the requirements for the designation as

UNDERGRADUATE RESEARCH SCHOLAR

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Associate Dean for Undergraduate Research: Robert C. Webb

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ABSTRACT

Neural Correlates of Sympathy. (April 2009)

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Sympathy has not been not fully studied in the context of neural processes. Thanks to new methods of brain imaging and recording, the emotions anger, disgust, desire, and fear have been intensely studied, and new theories centered on emotion have been born out of this research. Sympathy has been relatively untested in this field of emotional processing, and more research is required to determine how sympathy manifests itself in the brain, and how its functions differ in comparison to other emotions. In 2003, Decety and Chaminade used FMRI to study how the insular cortices, anterior medial cingulate cortex , amygdala, and visual cortices are associated with sympathy, but FMRI has temporal limitations.

Electroencephalogram (EEG) methodology is preferred, because of its high temporal resolution. EEG recordings were taken of 40 undergraduate college students. Participants were shown a series of pictures of human faces; half of the pictures were showing a neutral expression, and the other half were showing a fearful expression. The participants were randomly assigned to one of two conditions. In one condition, to induce sympathy, participants were asked to imagine what the persons in the pictures were experiencing. In the other condition, to induce a lowered sympathy state, participants were asked to try to remain objective while viewing the pictures. Data from the site P8 in the occipito-temporal area of the brain, which has been associated with face processing in previous work by Righart and Gelder in 2008, was extracted and analyzed at roughly 170 milliseconds after stimulus onset. Participants in a sympathetic state showed greater brain activation to fearful faces in this brain area. These results suggest that sympathy affects very rapid neural responses for people and may lead to greater processing and resource allocation for them.

DEDICATION

To my parents, who have always encouraged me.

Thank you for making me watch all of those NOVA programs that ended up getting me so inspired about science. Thank you for paying for my education as well, so I can follow my dreams.

ACKNOWLEDGMENTS

I would like to thank my advisor, Eddie Harmon-Jones, for supporting me through this project, and allowing me to mess around in his lab. Your help and advice has carried me through this project, and I know it will follow me further in my career.

I would also like to thank Philip Gable, who was always there for me to answer my questions, and stop me from freaking out. Without your help, this project would have gone nowhere.

Thank you, Carly Peterson, for helping me, being a friend, and getting me started on this great research journey.

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And lastly, thank you to the Department of Undergraduate Research. Without you, this thesis would not exist.

NOMENCLATURE

EEG	Electroencephalogram
EMG	Electromyography
Hz	Hertz
N170	Negative Peak at 170ms
P300	Positive Peak at 300ms
ERP	Event Related Potential
n	Number of Participants
ms	Milliseconds

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CHAPTER I

INTRODUCTION

Sympathy is an important social emotion that often motivates individuals to help those in need. A good deal of behavioral research on sympathy has been conducted over the last two decades (Batson, 1990; Batson, Turk, Shaw & Klein, 1995). Recent technological advances have been essential in assisting to understand the neural circuitry behind sympathy (Decety & Chaminade, 2003). Thus, this study will focus on the neurological basis of sympathy. This study focuses on study on the facial processing regions and how sympathy affects brain activation in these regions.

Empathy, or sympathy, involves the ability to comprehend and respond to the experiences and feelings being expressed and felt by another person, particularly when the other person is in need of help (Lamm, Batson & Decety, 2007). The three components of this emotion are "(1) An affective response to another person, which some believe entails sharing that person's emotional state; (2) a cognitive capacity to take the perspective of the other person; and (3) some monitoring mechanisms that keep track of the origins (self vs. other) of the experienced feelings" (Lamm, Batson & Decety, 2007). Thus our goal in manipulating sympathy must affect these areas.

This thesis follows the style of Brain Research.

The emotional response of sympathy to one in need is contrasted with the emotional response of distress to one in need (Batson, 1990; Batson, Early & Salvarani, 1997). Whereas sympathy has been found to cause altruistic or selfless helping behavior, distress has been found to cause selfish helping behavior (Batson, 1990). For instance, sympathy motivates helping regardless of the ease of escaping the situation. In contrast, distress only motivates helping when it is hard to escape the situation; if it is easy to leave, distressed individuals will leave and not help (Batson, Early & Salvarani, 1997).

These results and others suggest that sympathy should be associated with a motivation to approach the person in need, whereas distress should be associated with a motivation to avoid the person in need (unless avoidance is prevented by the situation). In line with the Motivational Directional Model, more approach motivated emotions ("going toward") should evoke more left frontal cortical activity, whereas more withdrawal related motivated emotions ("going away") should evoke more right frontal cortical activity. This model has been used to study emotions such as sadness, depression, and fear, which have been found to cause more right frontal activation. Emotions such as joy, excitement, and anger have been found to cause more left frontal activation (Harmon-Jones, 2007). The model has not tested sympathy, and thus it has the potential to shed light on this important distinction. Most previous studies examining emotion and frontal asymmetry have used alpha power derived from the electroencephalogram (EEG) as a measure of brain activity, because activity within the alpha range (8-13 Hz) is inversely related to underlying cortical activity (Lindsley & Wicke, 1974). FMRI has also found asymmetrical activations in frontal brain regions during emotional and motivational states (Pizzagalli, Shackman, & Davidson, 2003). In this experiment we enhanced the feeling of sympathy for the person in need. We hypothesized that increasing a subject's feelings of sympathy would cause the participant to want to approach the person in need. This approach should cause the participant to experience greater personal affinity with the person in the pictures, and possibly greater brain activation to the facial picture of the person.

In addition to examining left and right frontal cortical activation, the proposed experiment will examine the N170 component of the event-related brain potential (ERP). An event-related potential is the recording of brain activity directly after a predetermined stimulus. N170 is a negative going wave approximately 170ms after a presentation of a stimulus and has been found to be associated with facial processing and recognition in the occipito-temporal region of the brain (at site P8; Righart, & de Gelder, 2008). The N170 response has also been previous found to be increased in response to facial expressions of emotion (Campanella, Quinet, Bruyer, Crommelinck, & Gureit, 2003; Batty & Taylor, 2003). Although the N170 event-related brain potential has been implicated in processing of facial expressions of emotion, no previous research with EEG or ERPs has examined how sympathy affects this response. The proposed research will contribute to a more complete understanding of how sympathy may modulate rapid neural responses to faces.

CHAPTER II

METHODS

Participants

Forty right-handed participants were acquired via an online signup system through the Psychology Department at Texas A&M University. Seven participants were removed from the data analysis due to technical problems during their experiment. Participants were all were undergraduate students, the majority of which were male (51.7%) and freshmen (75.8%). There were six sophomores, no juniors and one senior. Participants were all enrolled in an undergraduate introduction to psychology course at Texas A&M University. Participants received credit towards a course requirement in exchange for participating in the research.

Materials

Thirty-two black and white photos of Caucasian faces were used in this experiment. Half of the photos were of male faces. The faces were photo-shopped so that only the face was visible and the hair and ears were removed (Fig. 1). The pictures depicted people with neutral facial expressions or with painful/fearful facial expressions. These pictures were taken from the NIMSTIM and Ekman's photo sets. Pictures were presented with timed DMDX programming software. Pictures were presented in random order, and all pictures were presented twice. All pictures were shown once, and then shown again in a different order. A 64 channel tin electrode EEG cap was used to collect the EEG data from the picture presentation.

Fig. 1 – Four Examples of Facial Pictures

Procedure

Participants completed a BIS/BAS survey and a Big 5 Personality questionnaire after informed consent was given. Sympathy and Empathy questions from the 45 Preliminary IPIP Scales were interjected into the traditional Big 5 Personality questionnaire. This was done so that relationships between personality differences and neural responses could be later examined. Electrodes were then affixed to the participant's face and scalp by a trained undergraduate lab assistant.

Participants were asked to watch a series of black and white photos of Caucasian men and women. Before viewing the pictures, they were told that these pictures were of people who were in an electric shock experiments that transpired earlier. They were told that some participants had been shocked, and some had not. They were then randomly assigned into two groups. The Objective group was told to remain objective and detached while viewing the pictures. The Sympathetic group was told to try to be sympathetic towards the people in the pictures and try to imagine how the people in the pictures feel. In the Objective group, participants were told "you will see pictures of people who were in an experiment involving electric shock. Some participants were shocked, others were not. Please try to remain as objective as possible. Do not let yourself get caught up in imagining what this person has been through and how he or she feels as a result. Just try to remain objective and detached". In the Sympathetic group participants were told "you will see pictures of people who were in an experiment involving electric shock. Some participants were shocked, others were not. Please try to imagine how the person feels about what happened. Imagine what this person has been through and how he or she feels as a result. Just concentrate on trying to imagine how the person in the picture feels".

Data collection and reduction

EEG was recorded with a 64 channel lycra cap using NEUROCAN software for impedance checking and data collection.

Electrodes were affixed to the corrugator (above the right eyebrow/eye) and to the zygomaticus (right cheek) muscles in order to measure if there was facial mimicry (Fig 2).

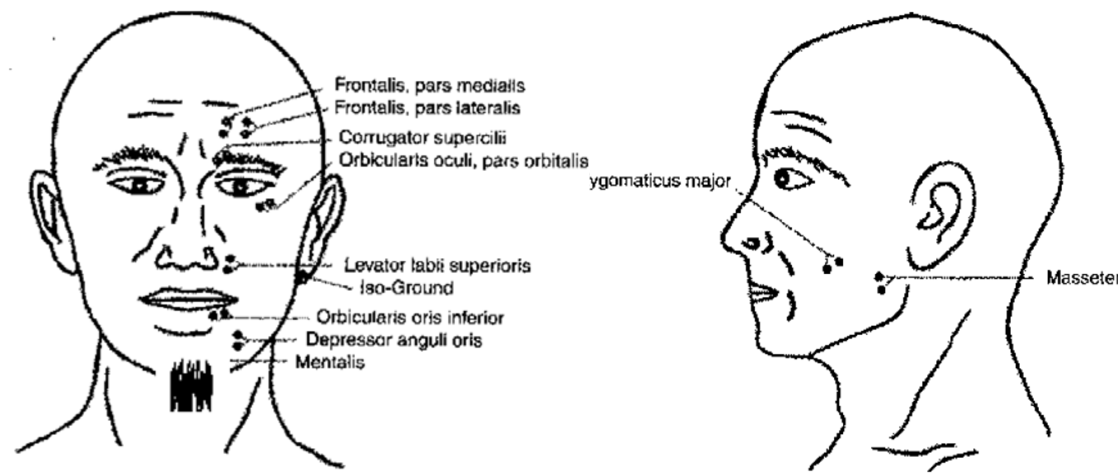

Fig. 2 – Placement of Facial Electrodes

Electrode impedances were under 5000 Ω; homologous sites were within 1000 Ω of each other. Signals were amplified, bandpass filtered (0.1-100Hz; 60-Hz filter enabled), and digitized at 500 Hz.

Data was visually inspected and portions of the data that contained artifacts were removed by hand. ERP group averages were computed for each picture and group type (Sympathy Fear, Objective Fear, Sympathy Neutral, and Objective Neutral, where, for example, Sympathy Fear is all fearful facial expression picture ERPs in the Sympathy condition). A regression-based eye movement correction was applied. ERP waveforms were visually scored to determine the windows used during peak detection. Power values within low alpha band (8-10.25 Hz) were averaged across epochs of picture viewing. Predictions were directional, derived from theory, and were evaluated using a one-tailed criterion of significance for Sympathy Fear vs. Sympathy Neutral. A two-tailed criterion for Sympathy Fear vs. Objective Fear, and Sympathy Fear vs. Objective Neutral was used (Rosenthal, Rosnow, & Rubin, 2000).

Zygote and Corregator data was not analyzed due to inconsistencies in collection, and lack of data as a whole from all participants.

CHAPTER III

RESULTS

Epochs were captured of the EEG data for 1-500ms after picture presentation from the P8 site. No significant results were found in sites P7, O1 or O2 for the calculated epochs. The same set of pictures was shown twice. Fig. 3 shows the grand average for both picture presentations across all subjects. The average ERP responses across all subjects are displayed as a function of the 2 (sympathy vs. objective viewing set) X 2 (neutral vs. fearful faces).

T-tests were computed for Sympathy Fear vs. Objective Fear, Sympathy Fear vs. Objective Neutral, and Sympathy Fear vs Sympathy Neutral. These t-tests were based on grand average ERPs across subjects and not on individual subject data (these tests will be performed in later analyses). There was a significant effect for Sympathy Fear vs. Sympathy Neutral in a one-tailed test. That test's highest t value was -1.566 providing a p value of above 0.01. There was a significant effect for Sympathy Fear vs. Objective Fear in a two-tailed test. The test's highest t value was -2.226, providing a p value of above 0.05. There was also a significant effect for Sympathy Fear vs. Objective Neutral in a two tailed test. The test's highest t value was -3.652, providing a p value of above 0.01.

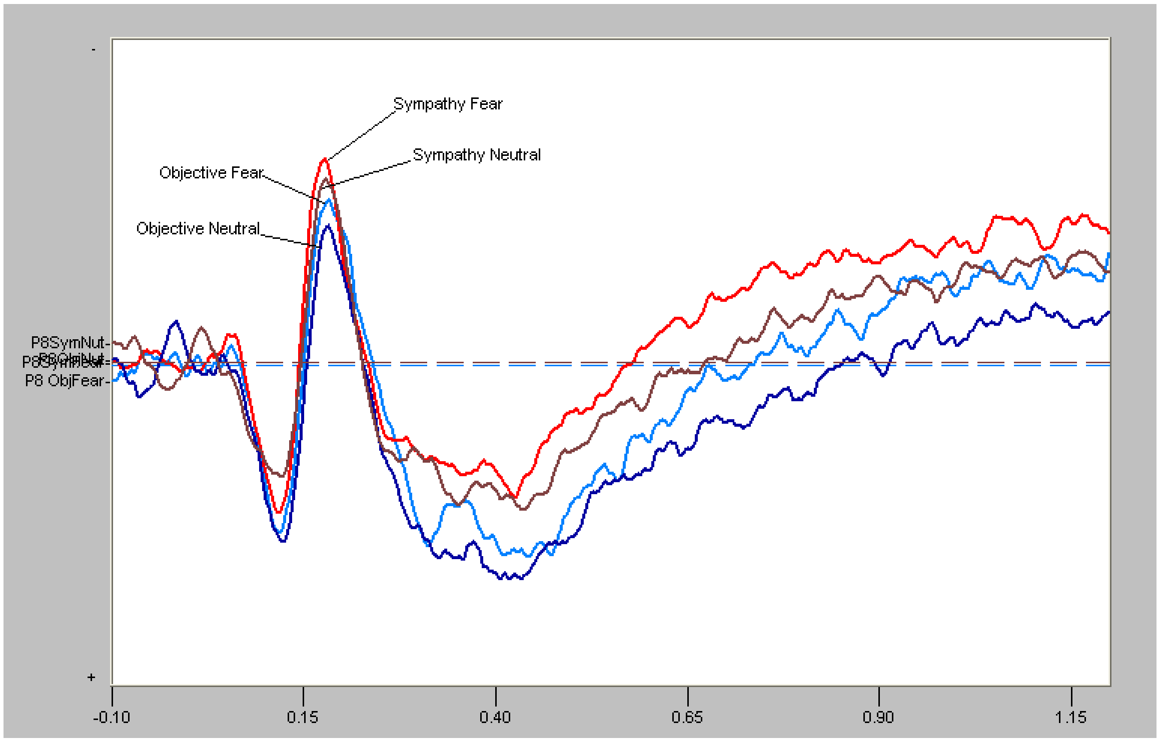

Fig. 3 – Facial Picture Epochs. Averaged across All Subjects and Picture Presentations

Table 1 shows the t-test scores for the above Figure (Fig. 3). The focus was on the N170 component of the ERP. Thus, areas around 170ms were analyzed.

Table 1 – T-Test Scores for P8 Facial Epochs

	Sympathy Fear vs. Objective Fear	Sympathy Fear vs. Objective Neutral	Sympathy Fear vs. Sympathy Neutral
Earliest Point of Significance (1 Tailed)			150.5ms t= -1.276 p < 0.1
Earliest Point of Significance (2 Tailed)	143.0ms t= -1.603 p < 0.1	127.0ms t= -1.645 p < 0.1	
Highest Point of Significance	152.0ms t= -2.226 p < 0.05	159.0ms t= -3.652 p <0.001	159.0ms t= -1.566 p < 0.1
Latest Point of Significance (2 Tailed)	166.5ms t= -1.636 p < 0.1	182.5ms t= -1.629 p < 0.1	
Latest Point of Significance (1 Tailed)			163.5ms t= -1.206 p < 0.1

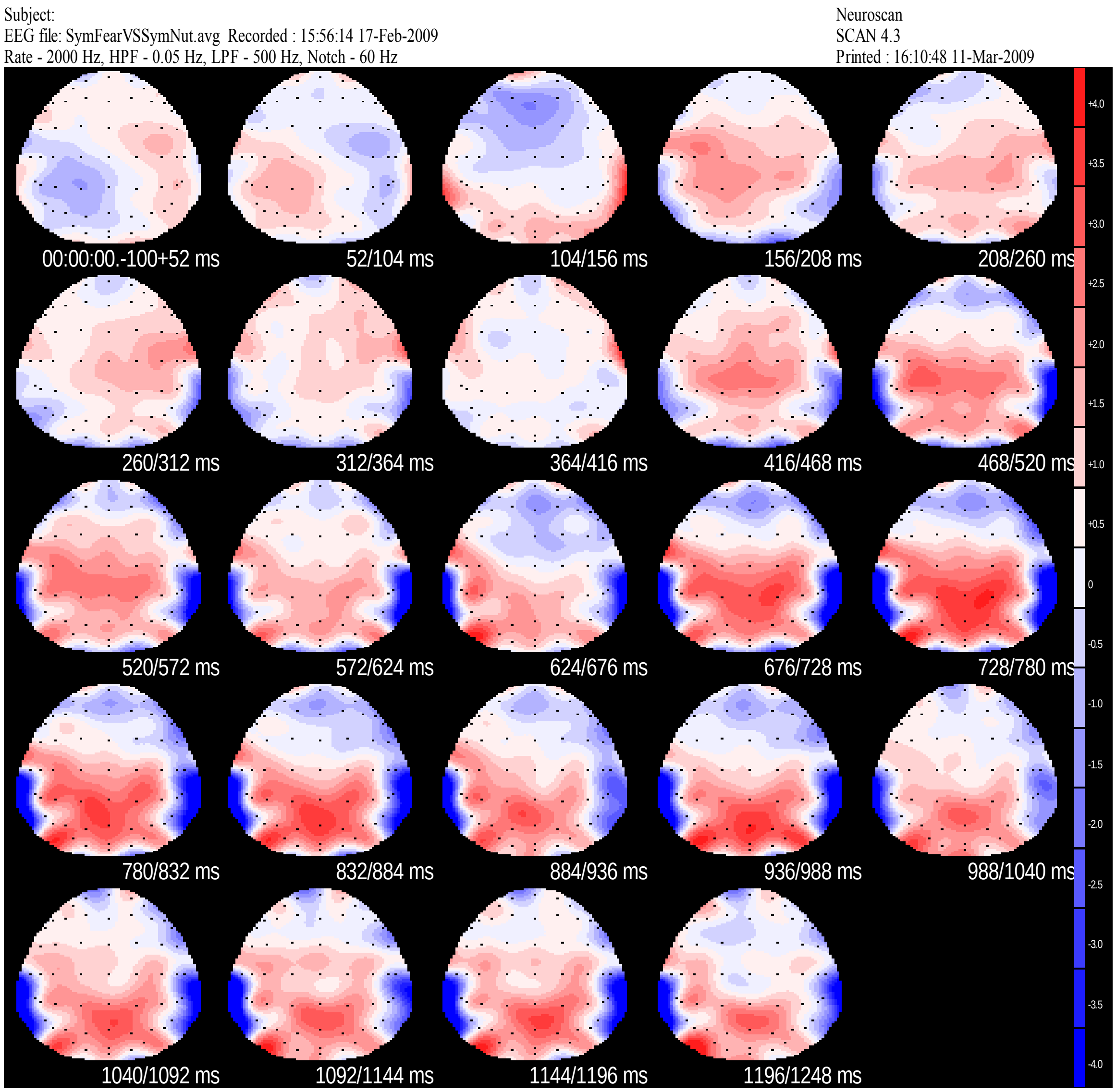

Figure 4 – T-Test for P8 Facial Epochs Sympathy Fear vs. Sympathy Neutral

Figure 4 shows t-test scores over time across the entire EEG cap comparing the grand averages for the Sympathy Fear Group vs. the grand averages for the Sympathy Neutral group. Darker red indicates more significant scores in the positive direction. Darker blue scores indicate more significant scores in the negative direction.

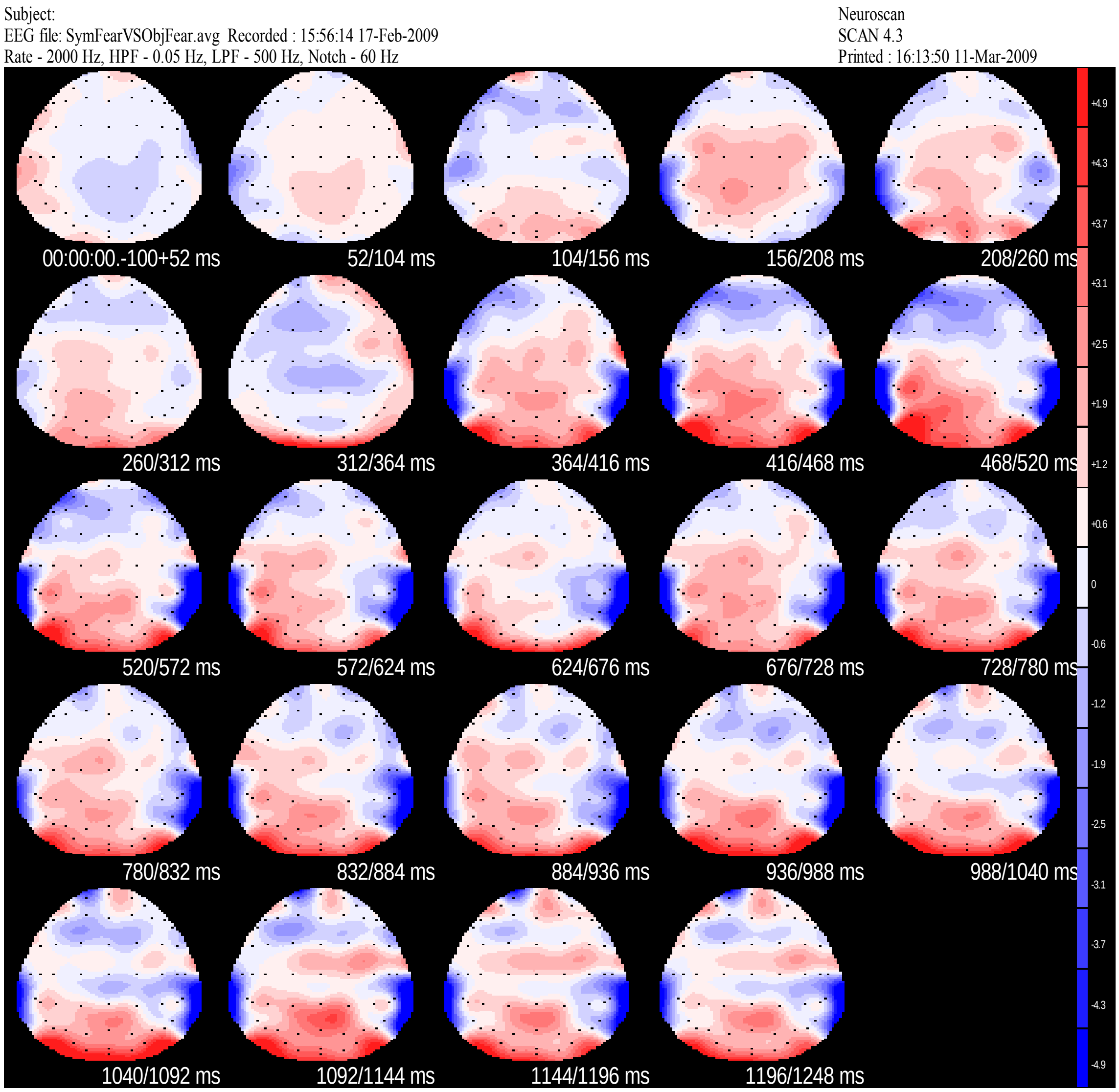

Figure 5 – T-Test for P8 Facial Epochs Sympathy Fear vs. Objective Fear

Figure 5 shows t-test scores over time across the entire EEG cap comparing the grand averages for the Sympathy Fear Group vs. the grand averages for the Objective Fear group. Darker red indicates more significant scores in the positive direction. Darker blue scores indicate more significant scores in the negative direction.

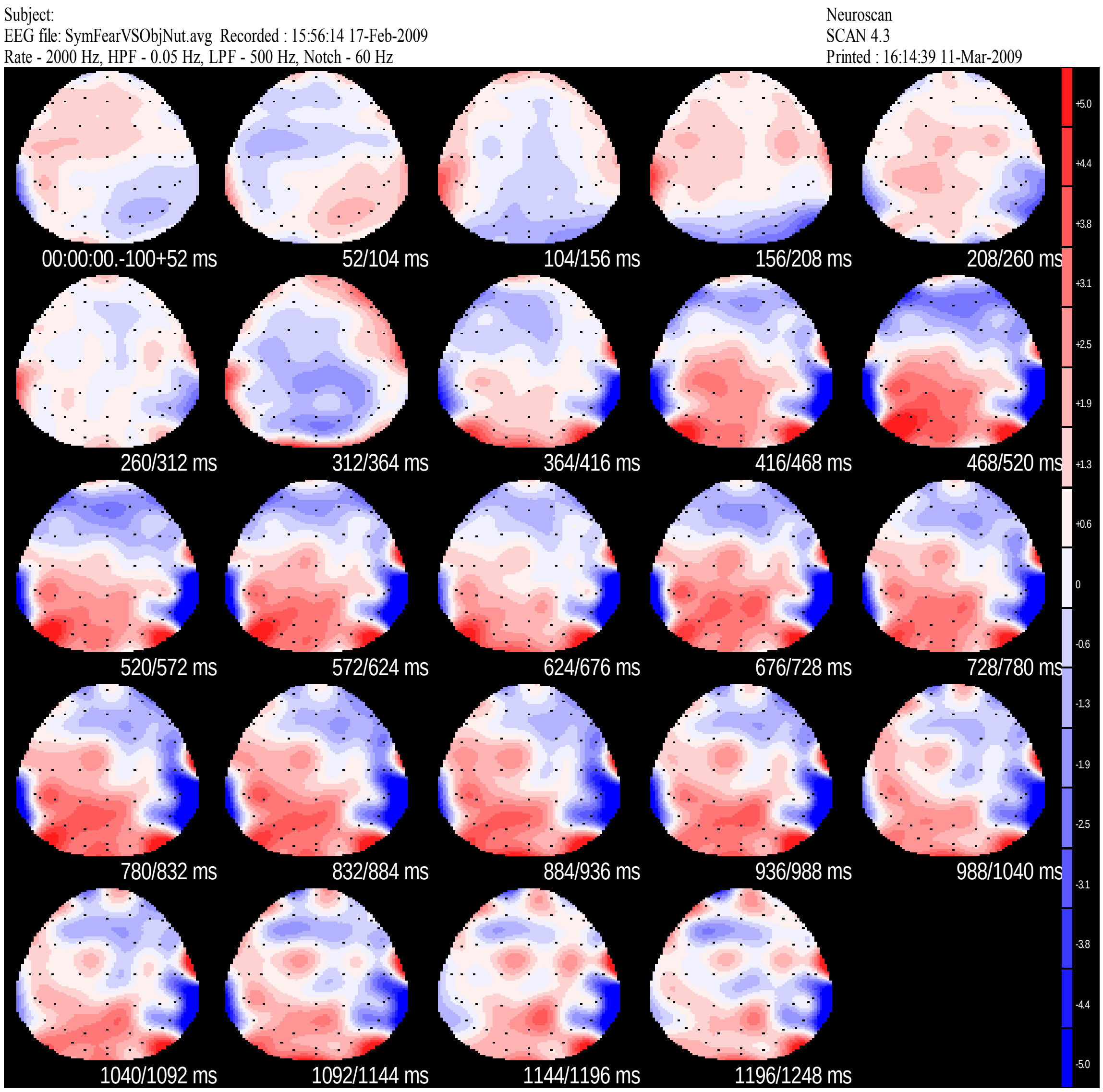

Figure 6 – T-Test for P8 Facial Epochs Sympathy Fear vs. Objective Neutral

Figure 6 shows t-test scores over time across the entire EEG cap comparing the grand averages for the Sympathy Fear Group vs. the grand averages for the Objective Neutral group. Darker red indicates more significant scores in the positive direction. Darker blue scores indicate more significant scores in the negative direction.

CHAPTER IV

SUMMARY AND CONCLUSIONS

Summary

Levels of brain activation in the occipito-temporal sites of the brain directly after a presentation of a facial picture stimulus were analyzed. This area has been found in past research to be associated with facial processing (Righart & de Gelder 2008) and the sympathetic response (Decety J. & Chaminade T. 2003). The present results extend past studies by showing that sympathy can modulate brain activations toward people very rapidly.

People who were told to take on a sympathetic state of mind showed greater brain activity to pictures of people displaying fearful expressions than they did when shown people displaying neutral expressions. They also showed more brain activity to fearful expressions than people in the objective group to either type of expression.
These significant results occurred at the N170 peak, roughly between 121ms and 188.5ms.

This data supports the hypothesis that sympathy is correlated with higher levels of brain activation in facial processing regions of the brain.

Conclusions

A higher level of brain activity in facial processing regions due to sympathy suggests that people may expend more energy attenuating to faces if they are in a sympathetic state.

This emotional activity may be a result of a desire to ‘approach’ the person in need in order to help, or provide comfort, and to be able to share in the emotional state of others people.

Future research

In the future, I think it would be beneficial for this line of research to look at frontal asymmetry to sympathy. As mentioned before, sympathy should be associated with a motivation to approach the person in need, whereas distress should be associated with a motivation to avoid the person in need (unless avoidance is prevented by the situation). A study that examined these two sides of sympathy would be highly beneficial to expanding the currently knowledge of emotions, and possibility strengthening the Motivational Directional Model of emotion.

Another physiological measure correlated with sympathy is the mirror neuron response. Mirror neurons are neurons in the “ventral premotor cortex” (Jacob, 2008) and have been first discovered in macaque monkeys. These neurons fired both when “a monkey preformed and action, and when it sat motionless observing another individual performing an action” (Oberman , McCleery , Ramachandran, 2007). This mirror system is “proposed to underlie many aspects of social cognition” (Oberman , McCleery , Ramachandran, 2007).One of those aspects is thought to be sympathy. The reason we can feel sympathy for others may be that this mirror system may be activated when we view the expressions of others, and we may actually feel a little of what the other person is feeling. This line of research would both help further understand sympathy, and also some aspects of Autism, as mirror neuron activity suppression has been correlated with Autism.

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