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Physiological Techniques for Measuring Empathetic Responses in Pre-Healthcare Students vs. Non-Pre-Healthcare Students

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Abstract

In a world with evolving healthcare systems, healthcare professionals are expected to experience and project empathy to a greater degree than they were in the past. The goal of this study was to determine the effectiveness of different techniques for measuring physiological and perceived empathy, as well as to compare data from pre-healthcare (PH) students vs. non-pre-healthcare (NPH) students to determine if there were disparities between the two groups. Physiological empathy was assessed using facial electromyography (EMG) to record data from the Zygomaticus major (ZM), Corrugator supercilii (CS), and Orbicularis oculi muscles (OO). The ZM muscle is generally associated with positive emotions, while the CS muscle is generally associated with negative emotions. The OO muscle has been shown to respond to some positive emotion as well as pain-related empathy, and may be another useful measure in empathy studies. Facial EMG has been shown to reflect neurological empathetic responses through fMRI studies. Data were also collected using galvanic skin response (GSR). Perceived empathy was assessed using the Jefferson Scale of Physician Empathy, which was administered both prior to and following a viewing of media that was designed to elicit an emotional response. Participants were also instructed to report perceived empathy using a push-button. Results showed that there were no significant differences between PHP and NPH students on any measures of physiological or perceived empathy. The OO muscle was shown to correlate strongly with both the ZM and CS muscles. The correlation was stronger between OO and ZM in the positive affective state (r = .701), and stronger between OO and CS in the negative affective state (r = .864). This finding suggests that the OO muscle responds to both positive and negative emotions, and is not likely to be a useful measure for inferring an individual's affective state.

Keywords: Empathy, Healthcare, Facial EMG, Physiological measures, Neuroscience

1. Introduction

Empathy is defined as an intellectual and emotional awareness and understanding of another's thoughts, feelings, and behavior[1]. In a world with evolving healthcare systems, physicians and other healthcare professionals are expected to experience and project empathetic behavior more-so than in the past. However, it is debated whether or not implementing empathy-related coursework would provide substantial benefit to physicians and other healthcare professionals due to a lack of reliable data. Therefore, it is essential to develop reliable methods for measuring and quantifying empathy-related data. In the past, subjective methods such as participant self-report were primarily used to measure empathy, and will be referred to here as "perceived empathy[2]." Although these types of methods may be useful, it is important to note that they may be subject to bias. In order to obtain more valid results, it would be useful to implement more objective methods for quantifying empathy. This may be accomplished by using psychophysiological measures of emotional responses, such as facial EMG, referred to here as "physiological empathy[2]." Using physiological measures of empathy, scientists can further explore this phenomenon and collect data objectively.

Although the phenomenon of empathy has long been observed, only recently have neural mechanisms for empathy been proposed. The discovery of mirror neurons has led some researchers to new theories concerning the neural basis for empathy[3,4,5]. Neumann and Westbury (2011) provide an exhaustive review of the psychophysiological methods for measuring empathy. Facial Electromyographic Activity (EMG), and Electrodermal Activity (EDA), also known as "Galvanic Skin Response" or "GSR" were among the methods discussed in this review. They conclude that facial muscles are particularly relevant for measuring affective states and empathy studies because of their association with the expression of facial emotions[2]. It is explained that the Corrugator supercilii (CS) muscle is contracted during frowning and is thus indicative of negative emotion, and the Zygomaticus major (ZM) is contracted during a smile and is thus indicative of positive emotion. They note that an advantage of using facial EMG to measure empathy is that it allows for the detection of facial muscle activity below the visual threshold, which makes it a more objective and sensitive measure than observer ratings. Neumann and Westbury explain that skin conductivity changes in response to activity of the endocrine glands of the skin. This means that EDA is indicative of sympathetic nervous system activation, which may indicate non-specific emotional arousal. In addition, they indicate that there is a significant correlation between the psychophysiological measures of empathy and the self-report measures. This indicates that psychophysiological measures may be particularly useful in the quantification of empathetic responses.

Although there is generally little disagreement concerning the indication of positive or negative affective states using ZM and CS in facial EMG, there has been some disagreement regarding which affective state is best characterized by Orbicularis oculi (OO) activation. Some researchers have used this muscle to infer positive affective states, while others suggest the OO muscle best reflects pain-related empathy[6,7]. The current study aimed to determine the effectiveness of using the OO muscle in facial EMG to infer general affective states by comparing it with ZM and CS muscle activation, in addition to self-report measures. Participants viewed media related to healthcare that was designed to elicit both positive and negative affective states throughout the film. Intervals in the film were assessed at both positive and negative affective states to determine if the OO muscle had a stronger correlation with the ZM muscle or CS muscle in these affective states. The study also separated participants into two groups: pre-healthcare students (PHP) and non-pre-healthcare students (NPH). The PHP group included pre-medical students, nursing students, and pre-physician's assistant students; while the NPH group included any university students not entering a healthcare field. It was hypothesized that NPH students would show higher levels of physiological empathetic activity than their PHP counterparts, and that the OO muscle would have significant responses in both the positive affective state and negative affective state.

2. Methods

2.1 Participants

Participants were recruited from a large urban college in the western United States. A majority of the students who participated in the study were enrolled in an Introductory Psychology class, and they received course credit as compensation for their participation. The study was conducted on a total of 28 participants (15 male, 13 female); 12 of whom were NPH students, and 16 of whom were PHP students (3 Pre-PA, 5 Pre-Nursing, and 8 Pre-Med). All participants were treated in accordance with the American Psychological Association's guidelines for human research[8].

2.2 Materials

Participants were provided with forms to collect demographic and perceived empathy data. The demographic information form asked participants to provide their ethnicity, the time of day that the study was conducted, the date, gender of the participant, as well as their area of study and intended career field. The pre-test questionnaires were designed to assess each individual's perception of empathy as it relates to healthcare prior to watching the film. The material in these questionnaires consisted of questions such as: "What is the responsibility of physicians to provide emotional comfort to a patient?" and "What is the role of nurses to provide emotional comfort to a patient?" and "In a medical encounter such as an office visit to a physician, which personnel do you most identify with? Explain." This questionnaire also requested that the participant provide their own definition of empathy. The Jefferson scale of Physician Empathy (Health Professions Student version) was administered both prior to and following a viewing of the media. The Jefferson Scale is a 7 point Likert scale, in which a response of "1" indicates a strong disagreement

and a response of "7" indicates a strong agreement with the statement[9]. The Jefferson scale consists of 20 total statements such as: "Healthcare providers' understanding of their patients' feelings and the feelings of their patients' families does not influence treatment outcomes." and "Understanding body language is as important as verbal communication in healthcare provider-patient relationships." Following a viewing of the media, participants were administered the post-test questionnaires, which were designed to assess what emotions the participant felt throughout the film, what characters they most identified with, if their perception of empathy changed as a result of viewing the media, and whether they thought there was added value in implementing empathy-related literature into the health professions by marking an indication on a 1-10 scale, with a response of "1" indicating no perceived value added and a response of "10" indicating high perceived value added.

The HBO film "*Wit*," developed from a play by Margaret Edson was used as the media for eliciting emotional responses in the participants[10]. The film depicts Professor Vivian Bearing's experiences with her healthcare providers in her final weeks as she battles Stage IV advanced metastatic ovarian cancer. As the film progresses, there is a stark transformation of her personality and ideology. Formerly being one who prefers scholarship over humanity, her poor experience interacting with her healthcare providers before her death leads her to understand the importance of humanity. Although the film is primarily "sad" in nature, it employs a level of humor in some scenes that can be used to assess positive affective states as well.

Physiological empathy data were collected using BIOPAC physiological recording units. In order to collect data from 5 channels for each participant, it was necessary to link two units together using an OUT3 BNC adapter and a BNC to BNC cable. This allowed for data to be collected from the push-button, ZM EMG, CS EMG, OO EMG, as well as GSR simultaneously for each participant. Facial EMG channels were connected to SS2LB lead sets, which were then connected to the pairs of disposable EL503 facial electrodes placed on each facial muscle of interest. The SS10 Push Button Hand Switch was connected to another BIOPAC channel to record perceived emotional responses to the media, and an SS57L EDA Lead was connected to the remaining channel to collect data from GSR. All physiological data were recorded in BIOPAC Acq*Knowledge* software (v 4.0.3). Statistical analyses were performed using IBM SPSS Statistics (v. 19). Physiological data were analyzed by pairing each muscle in each affective state using a paired-samples *t*-test in order to determine the level of correlation between each muscle in both the positive and negative affective states. PHP and NPH groups were compared using a one-way MANOVA that included all data collected in the study—with the exception of GSR data.

2.3 Procedure

Participants were greeted by a researcher upon arriving at the research annex facility and administered the pre-test materials; which included an informed consent form, demographic information form, the Jefferson Scale of Physician Empathy, and the pre-test questionnaires. Following completion of the pre-test materials, participants were escorted to a testing room and seated at a desk in front of a monitor. Facial EMG sites, as well as the distal portions of the second and third digit of the left hand, were cleansed with alcohol prep wipes prior to applying electrodes to the muscles of interest. All electrodes for facial EMG were attached to the corresponding muscle on the left side of the face (see Figure 1), and a ground electrode was placed in the center of the forehead for each participant. Participants were then instructed to refrain from eating or drinking during the study, and to avoid any unnecessary movement. A researcher then demonstrated how to use the push button to report a perceived empathetic response, and each participant was told to hold the button down as long as they felt they were having a response. After answering any additional questions, the researcher started playing the film on the monitor and began the data acquisition on an additional computer that was connected to the BIOPAC units. Once the film was completed, participants were disconnected from the electrodes and offered a cleansing wipe to remove any leftover residue from the electrodes. Each participant was then administered the post-test materials, which included an additional Jefferson Scale of Physician Empathy, as well as the post-test questionnaires. Following completion of the post-test materials, participants were administered a survey in order to receive course credit if they were enrolled in an Introductory Psychology class. The session was then concluded, and participants were debriefed and dismissed from the study.

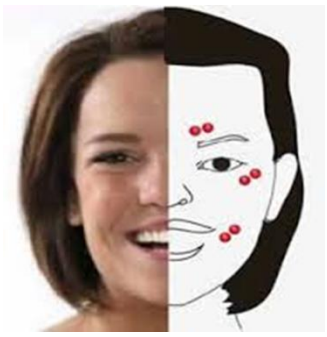

Figure 1. Displays the electrode placement for facial EMG. Two electrodes are placed on CS muscle above the eyebrow, on OO muscle under the eye, and on ZM muscle of the cheek. All electrodes were placed on the left side of the face, with a ground electrode placed on the forehead (not pictured).

3. Results

This study was designed to assess the effectiveness of using certain methods to infer empathetic reactions; specifically, whether facial EMG of the OO muscle is more representative of positive affective states or negative affective states. The study also aimed to determine if significant differences exist in perceived or physiological empathy between PHP students and NPH students. Facial EMG data were analyzed by taking the mean values for each measure over an interval during a positive affective state, as well as a negative affective state. A positive affective state is a state of emotion that is generally perceived as a positive emotion. These states were assessed at intervals in the film which incorporated humorous material. Conversely, a negative affective state is a state of emotion that is generally perceived as negative. These states were assessed at intervals during the film in which the patient was clearly mistreated. The means and standard deviations were calculated for each muscle group in each affective state by assessing mean EMG activation amplitude using the *AcqKnowledge* software, and can be found in Table 1.

Table 1 Descriptive statistics of each muscle group from the paired samples t-test, N = 28.

		Mean	SD
Pair 1	OO Neg Affect	.0001754	.00127701
	CS Neg Affect	.0006821	.00156646
Pair 2	OO Neg Affect	.0001754	.00127701
	ZM Neg Affect	.0018682	.00153873
Pair 3	OO Pos Affect	.0005089	.00123739
	CS Pos Affect	.0012414	.00110361
Pair 4	OO Pos Affect	.0005089	.00123739
	ZM Pos Affect	.0014493	.00149710

Facial EMG muscle groups were paired together in order to determine the relationship between activation of each muscle group, for example “pair 1” refers to the comparison of the OO muscle and the CS muscle in the negative affective state. A paired samples *t*-test showed that OO muscle activity had a stronger correlation with ZM activity than it did with CS activity in the positive affective state (r = .701). Conversely, the OO muscle had a stronger correlation with CS in the negative affective state (r = .864). A one-way MANOVA was used to assess all data between the PHP and NPH groups—with the exception of GSR data. Results of this test showed no significant differences between PHP and NPH on any measures of physiological or perceived empathy, F (12, 15) = .661, p = .762, Wilks’

$\Lambda = .654$. Descriptive statistics for all physiological and perceived empathy data between the two groups can be found in Table 2. While there were clearly differences between the two groups, the variability within groups made it difficult to find a significant result.

Table 2 Descriptive statistics for all physiological and perceived measures of empathy.

	PHP Mean (N = 16)	PHP SD (N = 16)	NPH Mean (N = 12)	NPH SD (N = 12)	Total Mean (N = 28)	Total SD (N = 28)
# of Switch Pushes	49.63	28.427	64.83	66.596	56.14	48.110
Jefferson Pre	109.13	12.382	103.83	13.644	106.86	12.966
Jefferson Post	116.00	13.813	112.25	12.159	114.39	13.031
Jefferson Difference	6.88	8.469	8.42	7.657	7.54	8.021
OO Neg Affect	.0003162	.00137495	.0000125	.00116511	.0001754	.00127701
CS Neg Affect	.0007850	.00169202	.0005450	.00116511	.0006821	.00156646
ZM Neg Affect	.0021250	.00158658	.0015258	.00146807	.0018682	.00153873
OO Pos Affect	.0004569	.00107911	.0005783	.00147007	.0005089	.00123739
CS Pos Affect	.0012075	.00107409	.0012867	.00118845	.0012414	.00110361
Zm Pos Affect	.0014538	.00160547	.0014433	.00140943	.0014493	.00149710
Added Value Likert Scale	7.94	1.482	7.75	2.179	7.86	1.779

4. Discussion

Results of this study suggest that the OO muscle is not an effective measure for inferring general affective states, because it responds strongly to both positive and negative emotions, as indicated by the strong correlation to the CS muscle in the negative affective state and the strong correlation to the ZM muscle in the positive affective state. However, it is possible that it may be useful for determining more specific responses (i.e. pain-related negative emotion). Future studies should investigate if the OO muscle is useful for deciphering between specific types of positive or negative emotion in addition to pain-related empathy.

There are several limitations when using facial EMG to infer affective states. For example, some disagreement exists within the scientific community about what empathy really is. It has been found that empathy is being used to describe 8 separate phenomena that may be distinct from one another, which brings the definition of empathy into question[11]. For instance, some define empathy as an intellectual and emotional awareness and understanding of another's thoughts, feelings, and behavior[1]. Others define empathy as the ability to share someone else's feelings[12].

It has also been noted that electrodes must be placed in precisely the same location on every test, because even small variations in placement can result in significantly different outcomes[13]. In addition, overlap of electrodes or placing an electrode in close proximity to another muscle may result in "noise" or "cross-talk"—unwanted recorded activity in the electrodes[14]. Future studies may want to consider using smaller electrodes than the EL503's, as well as implementing a low-pass filter in order to reduce the amount of unwanted electrical activity that gets recorded.

Another consideration for future studies is to standardize the mean EMG values for each participant before analyzing data, because there is generally a high amount of variability in baseline EMG readings between participants[14]. Implementing these methods could significantly increase the specificity, and therefore validity of the results. This method requires taking baseline EMG measures for each individual prior to recording EMG data during the experimental affective states. Mean EMG activation is then calculated and taken as a proportion of the baseline values to establish the standardized value. Although the current study did not implement this method due to a lack of baseline measures for each participant, future studies should take this into consideration.

It is also interesting to note that of the participants tested in the study, most indicated on the 1-10 Likert scale after viewing the media that they believe implementing empathy-related media or literature would be beneficial in a healthcare professional's education (PHP mean = 7.94, NPH mean = 7.75). A majority of the participants also indicated that they felt personally impacted by the film, and that their perception (however, not necessarily their definition) of empathy had changed as a result of viewing the media.

The findings in this study suggest that empathetic responses may in fact be measured using the methods described by Neumann and Westbury (2011). However, it is important to note some of the limitations of using facial EMG. Investigators should also implement a low-pass filter, as well as standardize EMG data for each participant before analyzing data in order to increase the specificity, and therefore validity of the results. These findings also suggest

that the true emotional representation, or representations, of some facial muscles have not been clearly established—although muscles like ZM and CS may be used to make general inferences about one's affective state. Therefore, the current study suggests that some muscles, such as the OO muscle, should be avoided when making basic generalizations about one's affective state until the parameters for these muscles have been more well-defined.

5. References

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