WHAT IS FACIAL EMG? *Heck, what is EMG?*

For our bodies to move, muscles are constantly contracting and relaxing. Electromyography (EMG) is a form of biometrics that measures the electrical activity of individual muscle contractions. The activity in facial muscles specifically is recorded by a facial electromyography, or fEMG.

What is fEMG?

For muscle activity to occur, our brain sends a signal. Our nerves play the role of Amazon and transport the 'package' to the right place (plus, it's a lot faster than two-day shipping).

When our muscles contract, there is electrical activity that moves through the tissue and bone. Brain signals travel through the spinal cord into the muscle by special neurons known as motor neurons. An even more specific type of motor neuron, known as the lower motor neuron (LMN), transmits signals o the neuromuscular junction (basically the bridge connecting two different parts of the body). If the muscle cell is at rest, there is a slightly negative charge. During this process of changing tension in the muscle, there is an electrochemical change which causes a positive flow of ions, a process known as depolarization. The change in current is picked up by EMG, helping us to catch changes in muscles that may not be visible to the naked eye. If there is a strong contraction, then there will be a higher activated muscle, and this will be reflected on an EMG recording by showing a high recorded voltage amplitude. Essentially, EMG accounts for the overall activity of the muscle whether or not we can visibly notice a change.

A positive or negative experience connected to a trend of physiological activity is how emotion is defined by Schacter, 2011. Facial EMG measures the valence of facial expressions that are associated with internal emotions. There are forty-three muscles in the face that are controlled by the facial nerve. Facial EMG can be rich in information to infer how respondents are implicitly reacting to stimuli on a muscular level. Luckily, fEMG is a noninvasive method to record facial muscles. Surface electrodes are placed in specific areas of the face that are associated with certain muscle groups (as shown in Figure 1). The three most useful muscles in determining emotional facial changes include: corrugator supercilii, orbicularis oculi, and zygomaticus major. These three muscles each are associated with types of emotional expression. Corrugator supercilii, a small triangular muscle located in the middle of the eyebrow, is linked to negative emotion. This muscle is affiliated with the furrowing of the brow. In fact, the name 'corrugator supercilii' translates in Latin to

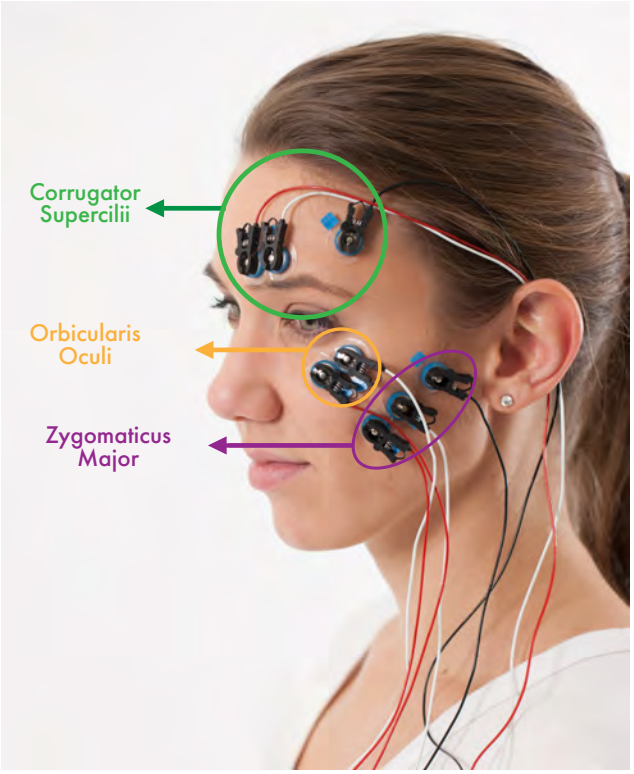

Figure 1

The three main muscle regions that are utilized in fEMG studies are indicated via color above: corrugator supercilii (green), orbicularis oculi (orange) and zygomaticus major (purple).

"wrinkle of the eyebrows." The corrugator supercilii is activated when exposed to something unpleasant or when frowning in concentration. Cohen, Davidson, Senulis, Saron & Weisman, 1992 reported using the corrugator supercilii muscle to measure attention when paired with heart rate.

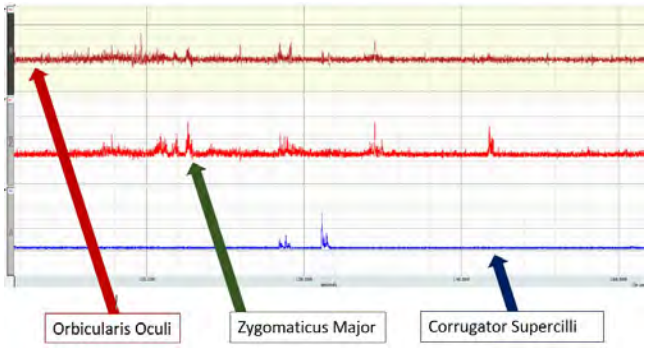

Figure 2

The fEMG output of the muscle activity from the three electrodes: Corrugator Supercilli, Zygomaticus Major, and Orbicularis Oculi.

Positive affect is associated with orbicularis oculi and zygomaticus major activity. The zygomaticus major is the muscle that raises the corners of the mouth while smiling. There has been some research suggesting that this muscle is also activated during a grimace, which is why researchers should record the zygomaticus major in conjunction with the orbicularis oculi. Information from the orbicularis oculi, located beneath the outer eye corner, can provide some insight into a startle eyeblink response. Something surprising such as a fire alarm or a door slam increases activity in the orbicularis oculi muscle. The orbicularis oculi muscle more generally is known for controlling closing eyelids. Ever heard of crow's feet or "smizing?" You can thank the orbicularis oculi for those lines of expression.

As researchers, it is important to accurately portray the data. Figure 2 is an example of the type of information that is collected from the fEMG electrodes. Facial EMG is very good at identifying positive and negative affect or emotional valence, but the exact emotion that is being elicited is challenging to definitively answer. An angry or sad emotion can both create activity in the corrugator supercilii muscle. Data from fEMG is useful to demonstrate that one stimulus is more positive, while another is more negative, on a valence scale. The data cannot, however, determine specific emotions. Another important area that needs to be cautiously discussed includes referring to the muscle regions or site activity rather than specific muscles. Crosstalk is when information from adjacent muscles is detected. This is due to the possible spread of electrical activity from the muscles by the time it reaches the skin. Each respondent also has unique muscle arrangements. To account for both human differences and crosstalk, extra precautions are taken by the research team to ensure that the information being extrapolated is scientifically sound and accurately reported.

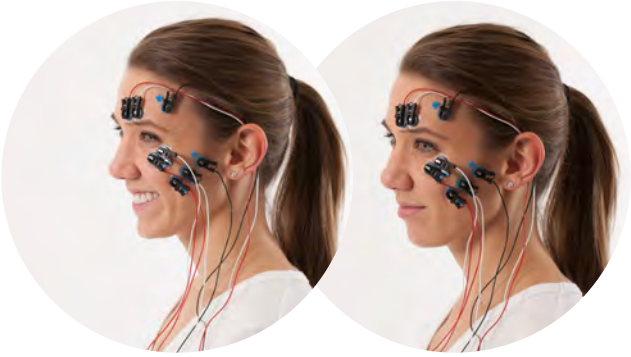

Figure 3

Duchenne smiles, also known as "smizing," is identified by the contractions of the zygomatic major muscle and the orbicularis oculi muscle. The zygomatic major muscle raises the corners of the mouth, while the orbicularis oculi muscle raises the cheeks and makes the eyes squint as seen in the left image. The right image is a non-Duchenne smile that only involves the zygomatic major muscle.

HOW IS fEMG TESTED?

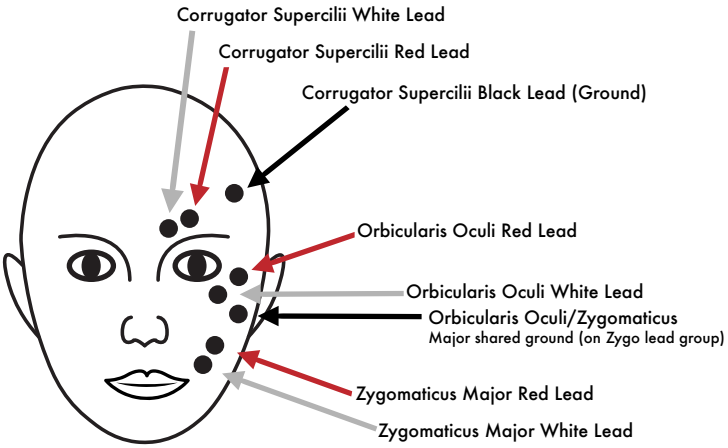

Figure 4
Facial EMG Lead Diagram

A fEMG recording can have a signal frequency between 10 to 500 Hertz. The signal frequency varies between each participant. Each individual smile can also elicit a different signal frequency. The amplitude of the signal is very small when the electrical potential is in contact with the skin. With this understanding, it is important that the researcher minimize electrical noise in any feasible way for the lab to get a strong reading from the fEMG. Unwanted noise can be caused by signal problems. Using an oil-free make-up remover to clean areas of contact is essential to confirm a strong signal. Keeping the room quiet and making sure the respondent is comfortable are other examples of how to promote better data collection. The fEMG will be able to detect if the respondent is expressing some type of unease. This is not only regarding the respondent-researcher interaction but can also include parts of the lab environment. For example, a bright light could result in the respondent furrowing his/her eyebrows. This reaction does not represent the emotional experience but shows that the respondent is trying to adjust to the environment. When interpreting the fEMG data, the researcher should take note of certain behavioral traits of the respondent that can influence the data. Chewing, laughing or even blinking can cause some excess noise, just like overhearing a person coughing nearby. Researchers must work hard to avoid having unintentional interferences. If something unexpected occurs, it is the researcher's job to note the complication so reading the data can include a fuller understanding of what is truly significant.

Figure 1 and 4 represent where the electrodes should be placed on the face when using fEMG. When conducting an fEMG study, the electrodes are set as a bipolar recording. This means that the difference between two electrode electrical potentials are measured. There also is a ground electrode typically placed on the forehead which is used to prevent noise from interfering with signals of interest. The waveforms within the software let the researcher know if everything is recording correctly. Being aware of potential pitfalls and how to avoid them is an integral part of how a researcher should be trained, thus helping to improve the quality of data being produced. Strong data creates a foundation for better interpretation and sound findings.

How could fEMG be helpful?

Facial EMG is a noninvasive modern system that allows researchers to investigate the valance of facial muscles in multiple contexts. The exposure can range from a wide array of stimuli. This could be useful in advertising, posters, packaging, radio advertisements, video games, logos etc. In 1999, Hazlett & Hazlett used television commercials to determine how effective fEMG was compared to self-reports. The findings suggest that fEMG provides a lot more qualitative information in analyzing the respondent's reactions to commercials. More recently, Mavratzakis et al., 2016 used fEMG to determine that variations in emotional face and scene processing can be observed at the neural and behavioral levels. Other researchers, such as Read, Ballard,

Emery & Bazzini, 2016 used fEMG to analyze responses to violent videogames. The wide application of fEMG demonstrates not only its versatility but also its ability to instantaneously detect and record implicit information of a respondent.

As with many biometric features, fEMG also has the advantage of unbiased measures of muscle activity. Language barriers are nonexistent, and fEMG is a very simple process for the respondent to follow. Researchers can also yield a lot of data from fEMG, and if trained well, can determine what components of the data are noteworthy. HCD works to promote and implement quality research by using the right tool for the right question.

IF YOU HAVE ANY QUESTIONS OR WANT TO LEARN MORE ABOUT HOW HCD CAN HELP YOU IMPLEMENT FEMG INTO YOUR RESEARCH QUESTIONS, PLEASE REACH OUT VIA EMAIL INFO@HCDI.NET OR CALL 908.788.9393.

CITATIONS

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