Nacke, Lennart, and Craig A. Lindley. "Flow and immersion in first-person shooters: measuring the player's gameplay experience." ***Proceedings of the 2008 conference on future play: Research, play, share*****. 2008.**

This paper reports the results of an experimental psychophysiological study investigating different traits of gameplay experience using subjective and objective measures. Participants played three Half-Life 2 game modifications while being measured with electroencephalography, electrocardiography, electromyography, galvanic skin response and eye-tracking equipment.

This study focusses on First-Person Shooter (FPS) games that put players in the first-person perspective. A qualitative study conducted by Brown and Cairns analyzed players' feelings towards their favorite game and led them to propose three gradual and successive levels of player immersion: engagement, engrossment, and total immersion. In a study by Ermi and Mayra, immersion was subdivided into three distinct forms: sensory(audiovisual execution of games), challenge-based(flow experience) and imaginative immersion(absorption in the narrative of a game or character).

The method used involved participants playing three-game mods; levels were designed for immersion, boredom, and flow. Facial electromyography (EMG) is a direct measure of electrical activity involved in facial muscle contractions; EMG provides information on emotional expression via facial muscle activation (even though a facial expression may not be visually observable) and can be considered as a useful external measure for hedonic valence (degree of pleasure/displeasure). Positive emotions are indexed by high activity at the zygomaticus major (cheek muscle) and orbicularis oculi (periocular muscle) regions. In contrast to this, negative emotions are associated with high activity at the corrugator supercilii (brow muscle) regions.

In Lang's dimensional theory of emotion, the valence dimension reflects the degree of the pleasantness of the affective experience. The other dimension, the arousal dimension, depicts the activation level linked to emotionally affective experience, ranging from calmness to extreme excitement. Arousal is commonly measured using galvanic skin response (GSR), also known as skin conductance. The conductance of the skin is directly related to the production of sweat in the eccrine sweat glands, which is entirely controlled by the human sympathetic nervous system. Increased sweat gland activity is directly related to electrical skin conductance. Hence, measuring both GSR and EMG provides sufficient data to provide an interpretation of the emotional state of a player.

Game experience questionnaire (GEQ) was used in this study to collect participant responses after each modality. The challenging aspect of flow seems to be the one best assessed with the GEQ as it shows a high increase in the flow level (which had gradually increasing combat challenges throughout the level). This leads to this level culminating in a very challenging end fight and thus might have been perceived as holistically more challenging, even though combat at the start of the level had the same density as in the immersion level. Overall, the GEQ results seem to validate the intended level design for the flow level. However, there seems not to be enough evidence in the data to subjectively discriminate between experiences in the immersion and the boredom levels.

The measurement of EMG responses was significant for the muscles indicating positive valence (orbicularis oculi and zygomaticus major). In addition, the measurement of arousal (galvanic skin

response) showed statistically significant differences under the different conditions manifest in the different level designs. The flow level scores highest for these conditions, making it a foundation for high-arousal positive emotions. This is a noteworthy finding since it links gradual challenges in a competitive environment to positive emotions.

As we discussed earlier in our meeting, galvanic skin response and facial electromyography can be good indicators for measuring immersion and flow while conducting our research with participants. Using the evidence provided by this paper, it is easier to understand how these techniques work for measuring certain factors/indexes. GEQ which was also mentioned in one of the previous research papers is a great resource and can be used for our research. GEQ along with the GSR and EMG can provide good evidence for us to start with.

In conclusion, the study reported here appears to show that physiological responses can be an indicator of psychological states of gameplay experience, as indicated by cross-correlation with subjective reports.