Creating Games to Consistently, Accurately Induce Excitement and Calming Emotions

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Abstract

Many students feel stressed throughout the school year depending on a variety of factors. School counselors, trying to help students cope with stress, often have a hard time pinpointing why a student is stressed or if they are feeling another emotion. It is important for school counselors to recognize what students are feeling and therefore look into this study as it serves to validate two sensors to detect stress within students.

1.0 Introduction

The economic cost of untreated mental illness is more than 100 billion dollars each year in the United States (NAMI California, 2020). While mental health issues affect all people regardless of age, race, and gender, schools can be a high pressure environment that stimulates mental health issues. School counselors often have difficulty assessing students' mental health based on their self-assessment surveys or just talking to them. Since emotion commonly arises in social areas, detecting negative and positive emotions is important in recognizing interpersonal problems. Biometrics are also a way to detect a universal basic set of emotions without the barriers of cultural differences (Flynn et al., 2020).

Undetected and misinterpretation of a client's state can lead to long-term mental health issues. This project provides an overview of how emotions can be categorized and potentially measured, describe the critical barriers that school counselors have in implementing this important task and identify arousal emotions by inducing and detecting emotions with games.

1.1 Characterizing Emotion

Emotion is a mental reaction (such as happiness or stress) subjectively experienced as a strong feeling that is accompanied by biometric changes within the body such as changes in heart rate, skin conductivity, and skin temperature (Merriam-Webster, n.d.). Emotion can be compartmentalized into three different components: valence, arousal, and dominance. As shown in Figure 1, each component is described by a range of factors. (Cai, et al. 2023).

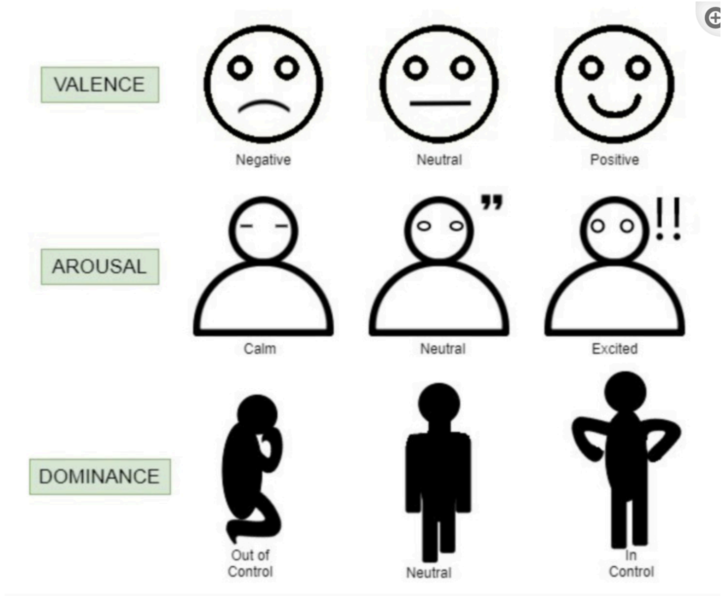


Figure 1: Valence, Arousal, Dominance (VAD) Model

Emotions are accompanied by unconscious physiological reactions, changes in biometrics (heart rate, skin conductivity, and skin temperature), that can be measured with sensors. While arousal emotion can be detected by heart rate and skin conductivity, valence emotions require a third sensor, skin temperature.

1.2 Biometrics

Sensors can detect increasing and decreasing trends and determine the emotional state of an individual. For example, when a person is stressed, the body releases hormones that send blood to the muscles which cause the body temperature to increase. Although arbitrary changes in heart rate can occur by consciously controlling breathing rhythm (Pokrovskii et al., 2012), using biometrics to measure and detect emotion avoids bias because humans cannot consciously control their heart rate, skin temperature, and skin conductivity, while in a controlled environment and maintaining steady breathing. The specific relationship between biometric measurements and emotion components are shown in figure 2. There have been many ways to detect emotion depending on specific needs, as shown in figure 3.

	Skin Temperature	Galvanic Skin Response (GSR)	Heart Rate	Time Needed to Measure
Arousal - Excited	-	increase	increase	short-term
Arousal - Calm	-	decrease	decrease	short-term
Valence - Positive	increase	increase	increase	long-term
Valence - Negative	decrease	increase	increase	long-term

Figure 2: Biometric to Emotion Chart

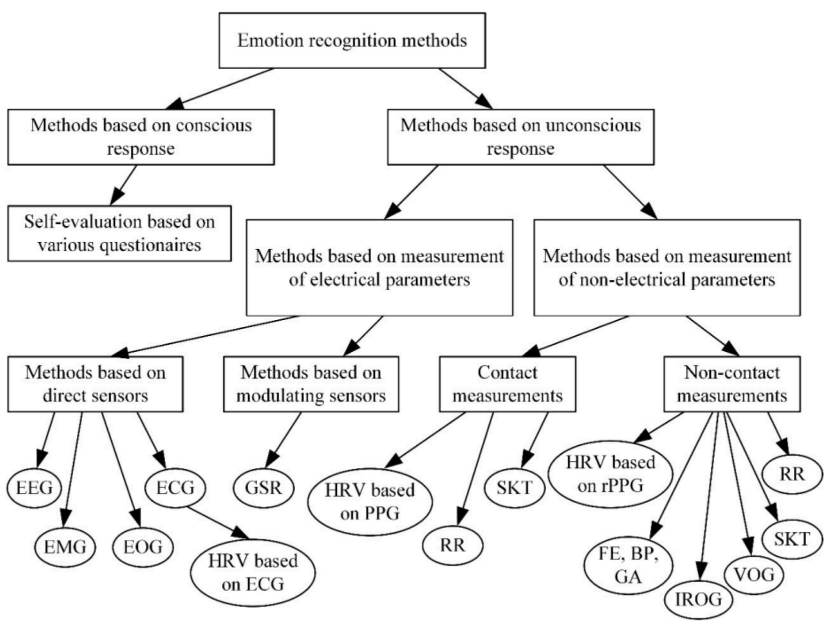


Figure 3: Emotion Recognition Methods Flowchart (Dzedzickis et al., 2020).

Galvanic skin response correlates directly to emotional arousal as the autonomic nervous system secretes sweat from eccrine sweat glands located on the palms of the hands. Electrical conductance of the skin depends on this sweat reaction, which reflects changes in the nervous system. The only downside of using GSR alone without other biosensors is that it has a weakness in detecting valence emotions (Mancini et al., 2019).

Photoplethysmography (PPG) is a technique to detect a change of microvascular blood volume in tissues or heart rate. PPG is performed by using one sensor attached to the finger with an LED. Using PPG to measure the individual's heart rate is useful for emotion recognition as it directly correlates with emotional states. The only drawback is that heart rate is typically measured over a long period of time to identify changes. Therefore, a change in heart rate by emotional stimuli is better measured during a long process because a short process will not show much change especially when inducing acute stress.

Skin temperature is best for spontaneous emotion recognition due to the autonomic nervous system that is not consciously controlled by the human body. It is also related to the human heart and sweat activity that link to ECG and GSR. Negative emotions like stress, anxiety, anger, embarrassment and others will cause a decrease of temperature. Skin temperature alone does not indicate an emotional change or reaction. Just like if GSR was used alone, it cannot accurately measure emotional change instantaneously. Skin temperature must be measured in a long term setting to see results, but by combining it with other sensors like the GSR and ECG, it can be used to reflect the influence of emotion on the nervous system (Dzedzickis et al., 2020).

1.3 Inducing Emotion

Emotion is an important window into the psychological state of people and its recognition can be useful to help navigate social interactions such as in school, workplaces, and also social media. In order to detect emotion correctly, intentionally inducing emotion is a key factor in proving its accuracy. In order to induce emotion, the individual needs to experience a reaction through emotional stimuli. Emotional stimuli can include anything with the five senses, such as auditory or visual stimuli. Listening to music, watching movie scenes, or playing games give the individual enough stimuli to produce a reaction. Emotion can be detected by using biosensors with the stimuli simultaneously. Most biometric sensors need to be used or paired with other sensors to prove its validity and accuracy. Biosensors that are commonly used are skin temperature (SKT), galvanic skin response (GSR), and electrocardiography (ECG) (Dzedzickis et al., 2020). All of these biosensors are a quick and cheap way to detect human biometrics.

Today, physiological signals are also used to detect human emotion (Maruf et al., 2023). Emotion detection would benefit from enhanced identification and classification of emotion for medical professionals, such as school counselors, therapists, and psychologists. Emotion detection has been used to diagnose schizophrenia and other mental disorders (Tripoli et al. 2022). Currently, school counselors and therapists rely heavily on self-reporting of emotions, resulting in potential bias that may interfere with accuracy. During a conversation with our school counselor, she mentioned that she struggles with the self-report forms since she has found discrepancies between the form and observing the student in real time. Sometimes students are using stress as an excuse for poor performance and the counselor has no way to validate or prove that they're genuinely stressed in order to support them (N. Nardon, personal communication, 5 October 2024).

1.4 Literature Review

In a study done by Mancini et al., 2019 as part of the Forensic Sciences Research in the University of Windsor, basic human emotion detection using galvanic skin response (GSR), heart rate (HRT), and facial video was tested by having individuals watch a series of movie scenes. All individuals were shown 7 videos, each one representing 7 emotions: joy, sadness, anger, surprise, disgust, contempt, and fear. Each video is supposed to elicit their respective emotion. The individuals were also being recorded for their facial expression as a way to validate their process and detect valence emotion. The authors determined that an individual experiences only arousal emotion in a long term setting. In addition, using heart rate alone did not allow researchers to differentiate the emotional changes. During strong emotional experiences, subjects also exhibited peaks in GSR. This study, however, does show that GSR and heart rate can indicate arousal.

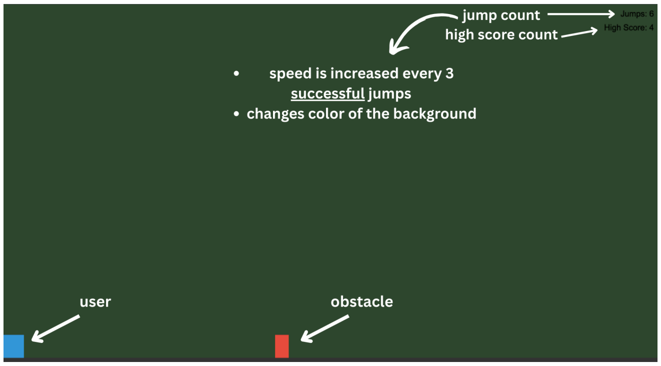
A study of emotion stimulation at INSEAD, a business school in Paris, was performed by (Yang et al., 2018) selecting the football simulation game *FIFA 16* for respondents to play. *FIFA 16* was chosen in particular due to short repeated events, close relation between emotion and event, and changeable difficulty level to provide different experiences. To analyze the participants' biometrics, ECG (electrocardiogram), EDA/GSR (electrodermal activity/galvanic skin response), EMG (electromyography), respiration, and body movement were measured. A protocol was designed to move participants through several different arousal events in the video game. While the FIFA16 video game simulation was not inducing emotion, the problems may have been with the media itself and encourages us to create customized games with the purpose of inducing emotion. After each half-time game, the respondents then filled out a self-assessed game experience questionnaire to further validate a sign of emotional arousal. As a result of these experiments, the authors found that the effectiveness of stimulation using a video game varies for each subject. This study highlighted the important need to reliably induce emotion in games where we could freely customize the specifications and adding a self assessed game experience questionnaire to our experiment.

1.5 Problem Statement

This project aims to help school counseling departments, as they need a way to measure students' negative and positive emotions, without bias, at school in order to guide/support them. School counselors often have a hard time assessing what a student is actually feeling only based on self-assessment. Previously developed devices are difficult to validate. Being able to detect emotions with an individual's biometrics, without bias, could help determine the right course of action for each student. With this data, counselors and medical professionals can determine when students or patients are aroused or calm and stressed or happy. Counselors could also keep a long-term log of data that can show a specific student's trends like if a certain class, teacher, or project stresses them out consistently. Using biometrics to detect emotion eliminates any bias in self-assessments and gives professionals a clear understanding of what their client is currently experiencing.

2.0 Methods

The game also alternates between harsh colored backgrounds and shows the player their points and high score in the top right corner. In order to raise the stakes, each player has 4 lives to achieve a high score. To ensure that the game induces a "stressed" emotion, the game uses a changing background every 3 jumps along with fast-paced sounding music. Throughout the game, a sound effect for each jump or press of the spacebar is present. The calming game is the same format as a basic Tetris Game. In order to add to the calming aspect, it uses pastel colored blocks. It also has no point system so the player cannot track their progress. It is an infinite Tetris Game because as the player fills up half of the rows, the bottom row deletes, allowing the player to continue gameplay without the stress of losing or approaching the top row.



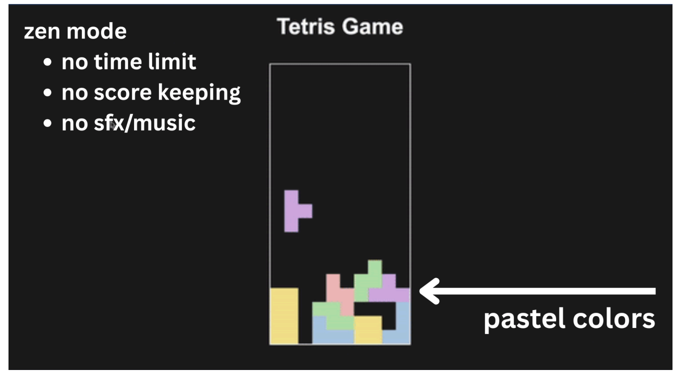


Figure 4: Block Jump Game

Figure 4: Tetris Game

The purpose of our first two phases of the project are to robustly validate our sensors and validate that our games consistently induce excitement or calm for arousal and happiness or stress for valence. The last phase involves using our system in an open environment, specifically in the school classroom. In order to determine whether an emotion is positive, our games need a way to consistently induce excitement and calming emotions with our sensors. Once we reach arousal emotion, then our games need a way to consistently induce stress and happiness with our skin temperature sensor to confirm that we can detect valence emotion.

2.1 Devices

A Grove Heart Rate sensor and a Galvanic Skin Response sensor were coded with an Arduino. Our heart rate sensor measures heart rate in beats per minute and our GSR sensor measures skin conductivity in ohms, the reciprocal of siemens. Once our sensors were coded, we validated them with breathing techniques and changing the environment while watching the serial plotter and the differences in values. We take the baseline HR and GSR of each player before any gameplay since every individual's biometrics are different, having it run through a code where it takes the user's BPM and GSR values as it averages the values out for a minute. Our second piece of code during gameplay takes each value of the GSR (blue line) and BPM (red line) every 5 seconds to smooth out the graph output. Throughout gameplay, the player keeps their nondominant hand on a rag in order to reduce the error margin for increased conductivity as palms of hands get sweatier while sitting on a surface.

2.2 Game Play

Two different games were created to induce an excited and a calm emotion. The "excitement" game is a simple Block Jump Game where the player uses the spacebar to jump over oncoming obstacles with the obstacles approaching faster and faster as the game continues and as the user progresses well. The calming game is an infinite tetris game where the participant uses the arrow keys to rotate each block to fill in a line. Once the participant gets to the middle row of the tetris game, a row is automatically deleted each time.

2.3 Validation Protocol

To analyze our data, we find spikes and drops in the GSR and HR values that indicate the state the player is in, an increase or decrease below or above the baseline as well as increasing and decreasing slopes that indicate the process that the player is. A decrease in GSR and an increase in HR indicates the player is in a state of excitement or stress and vice versa to detect a calm state. We also analyze the slopes of the graphs to determine the process the player is in since the process of exciting or calming doesn't create an immediate, significant change in biometrics.

After testing ourselves and other students with the simple games for arousal and calm emotions, we made changes in our game design to display more significant changes in biometrics or to make the player feel more aroused and calmer. Each of the sensors was validated individually. The heart rate monitor was validated by comparing its data to a heart rate app. The GSR monitor was validated by seeing an increase in number after sweating through physical exertion. Both games are measured with the GSR and heart rate sensor. A successful test of the arousal game should produce an increase in heart rate by 10-20 beats per minute above baseline and an increase in GSR. The calm game decreased heart rate and skin conductivity as it is intentionally designed to make the user calm and return back to baseline. After the experiment, the player is given a post-game survey for more data collection and to find any potential external factors that played into the results. We completed a success criteria worksheet to validate our system based on the data from the sensors. If there was too much noise produced by the device, the results would become uninterpretable.

(worksheet linked here:
https://docs.google.com/document/d/1Iy5XyN5Yl0Ou0P6TcoKWeLzsaPf0jmefm2X2wPUCwhk/edit?usp=sharing)

3.0 Results

After conducting 10 tests, we found that there was a consistent decrease in the beginning of the GSR rate and an increase towards the end. Although oftentimes we did not see as significant of a change as 10-20 beats, we still found increasing trends just not to this extent. The player plays the games and switches over while the code continues to run. It is important to note that if the player's GSR increases and the heart rate also increases, the user is considered to be in a "neutral state" with no way of interpreting it as either stressed or calm. In these graphs, all users start with a decreasing GSR as they start the block jump game. As the speed increased in the block jump game, 8 out of 10 players found an increase in heart rate above their baseline and a GSR drop below their baseline.

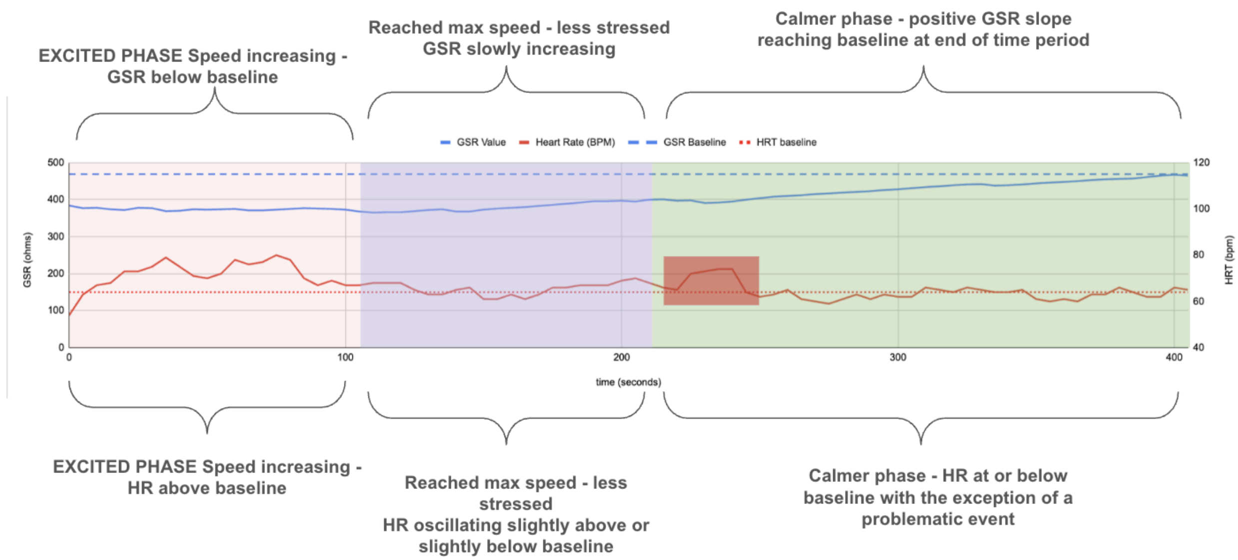


Figure 6: Moderate Example of Typical Pattern

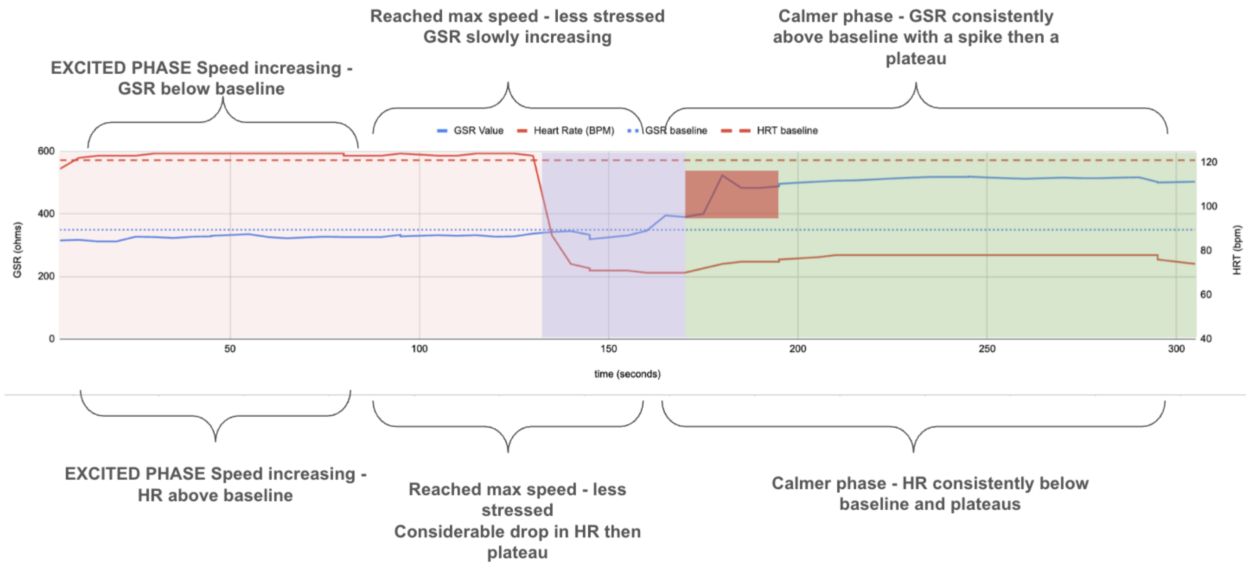


Figure 7: Dramatic Example of Typical Pattern

Figure 6 and Figure 7 display the intended pattern and trend that reach our success criteria. Our success criteria being that their biometrics validated the intended induced emotion. For the block jump game, intended to induce excitement, marked by the red phase, there should be a GSR decrease and an HR increase. For the tetris game, intended to induce calm, marked by the green phase, there should be a GSR increase and an HR decrease. 8 out of 10 players displayed either a dramatic or moderate pattern similar to the figures above. The dramatic pattern still reached our success criteria but we considered it “dramatic” because, based on her questionnaire, she was already excited and started laughing while taking her baseline. This made her baseline exaggerated as well as the rest of the results more dramatic. There were two outlier graphs that displayed problematic results. We noticed that all of our problematic results are within our first four tests (Test 1 and Test 4) so the issue could have been within our procedure or timing which improved with practice with trials. All of our graphs and trials can be found in the appendix.

Dramatic Typical Pattern	**Moderate Typical Pattern**	**Problematic Pattern**
Reese A. (Test 3)	Ava N. (Test 2)	Shannon G. (Test 1)
	Abby P. (Test 5)	Sophia A. (Test 4)
	Chelsea T. (Test 6)	
	Audrey P. (Test 7)	
	Isabella C. (Test 8)	
	Hailey L. (Test 9)	
	Olivia L. (Test 10)	

Figure 8: Summary Chart of Experiments

4.0 Discussion

Two video games were created to induce states of calm and excitement in the participants. The arousal states were verified using measurements of heart rate and GSR. As the main goal of the tests were to make sure our games produced stressed and calming emotions, it was important to note that there was a consistent pattern in 8/10 of our graphs. The user starts off decreasing as they are put into the test with the block jumping game that is supposed to induce a stressed emotion.

Every time the GSR drops, we would expect to see an increase in heart rate which meant that they were stressed. When the player's biometrics started to rise, our algorithm marked it as a neutral state, however the player was getting back to their baseline state after the stressful block jump game. Regardless, when the GSR increases, the HR is expected to decrease, meaning that the player is calming down. The gradual rise in the GSR signifies that the player has switched over to the tetris game and is in the process of calming down. By coding two games, we validated our sensor system knowing that one game is meant to induce stress while the other will induce calm and we found changes in the biometrics according to the chart and prior research with emotion detection. Therefore, we concluded that we were successful in making an emotion detection system where the sensors could pick up the changes in biometrics.

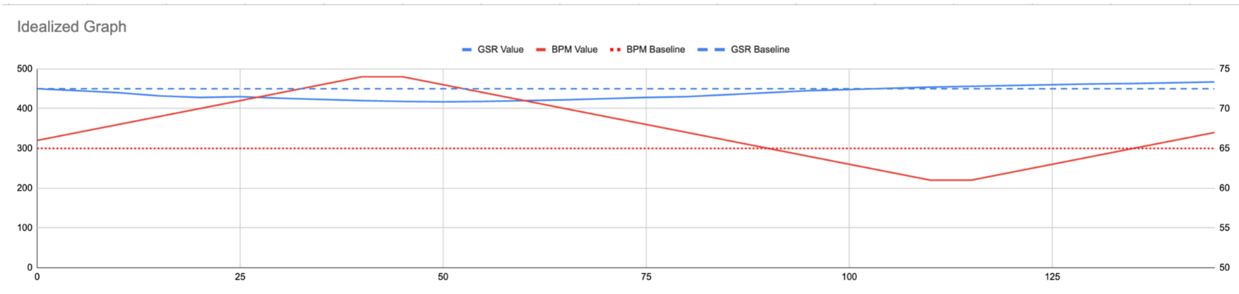


Figure 8: Idealized Graph

4.1 Future Work

Once the system can accurately detect arousal with validation, we would move on to developing a system that tests for valence using a skin temperature sensor. To completely ensure that our first phase is successful, a blind test of a user playing either game with only interpreting their biometrics is needed. We would also develop new games where they will technically be arousing the player, but the distinction between valence is that skin temperature can experience a rapid, short-term drop when stressed or an increase in temperature when happy.

5.0 Conclusion

After validating how biometrics directly correlate with emotion, we created a system and algorithm where we can consistently induce emotion and have these sensors used for stress testing. The system can be used by school counselors to accurately tell and interpret if a student is stressed or not. In addition to detecting stress vs. calm emotion, a future addition to the system would be the skin temperature sensor in order to reach and validate valence emotion. Detecting valence emotion would provide a more accurate and clearer emotion for the counselor to find out of the student.

Acknowledgements

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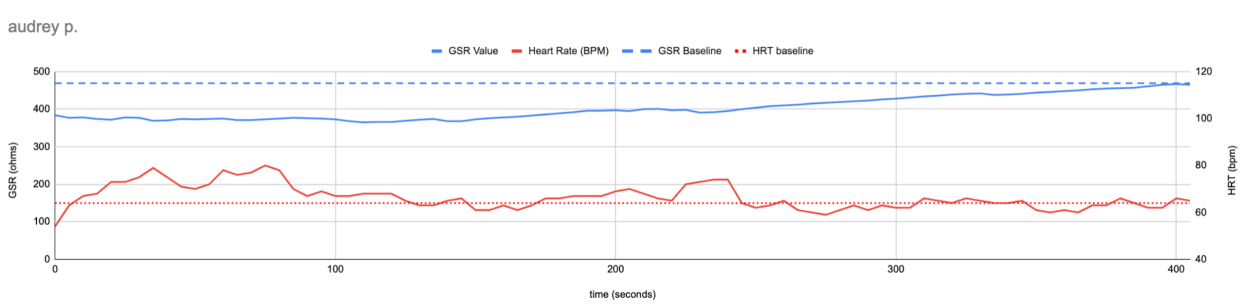
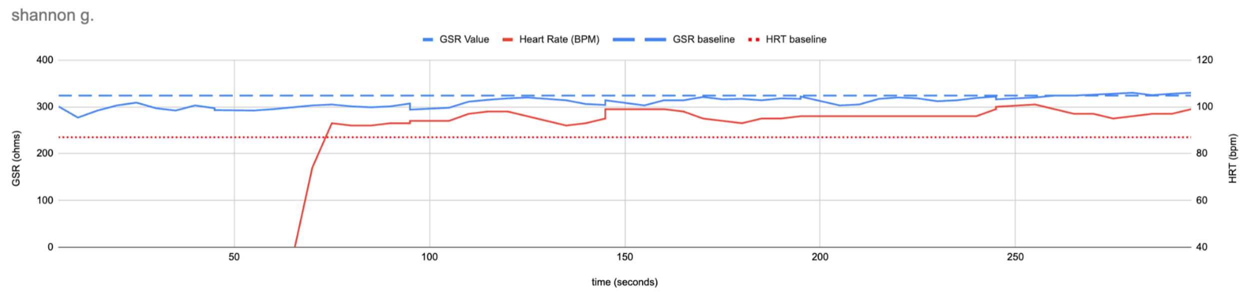
7.0 Appendix

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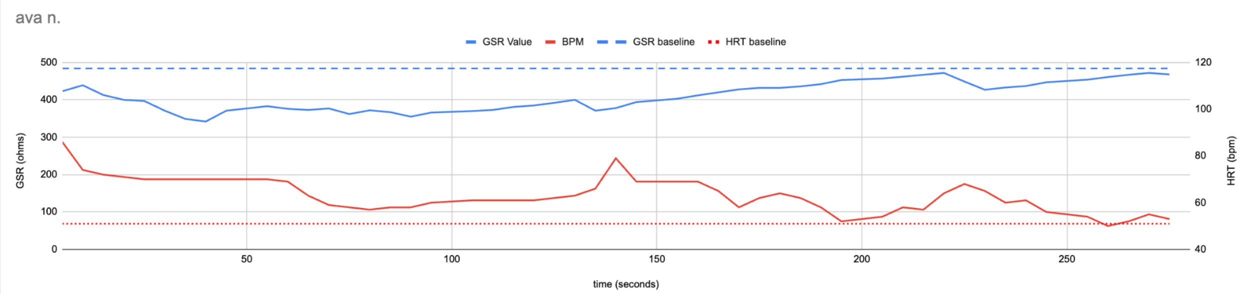
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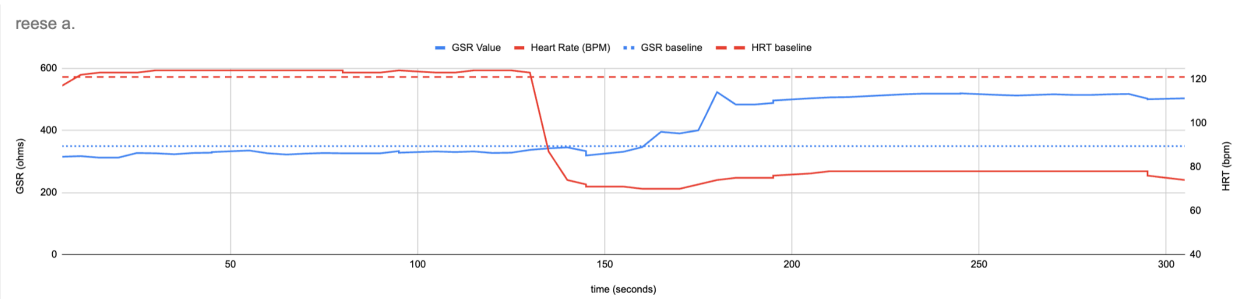
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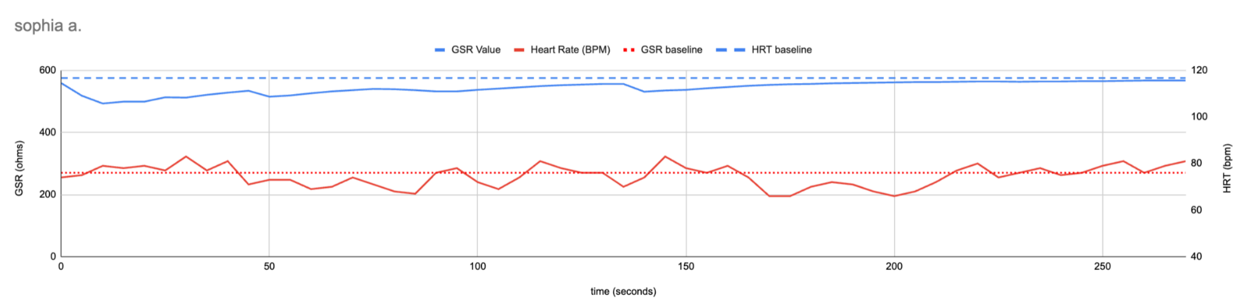
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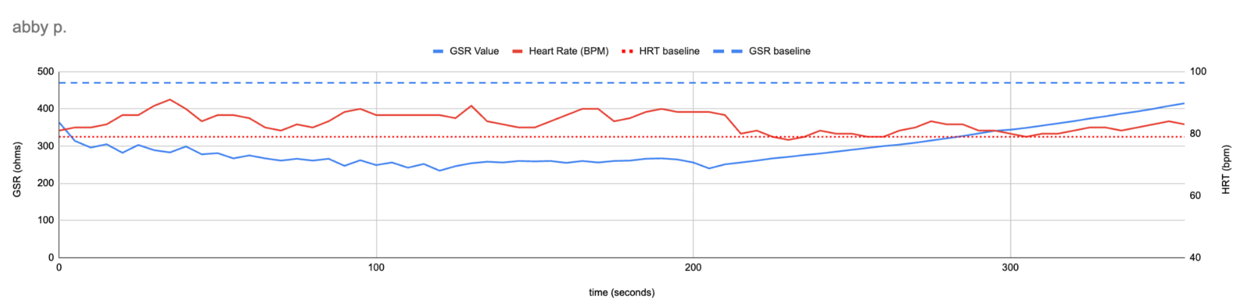
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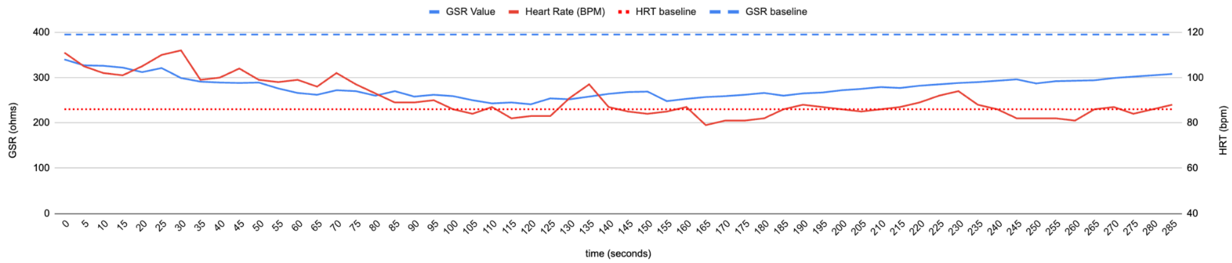

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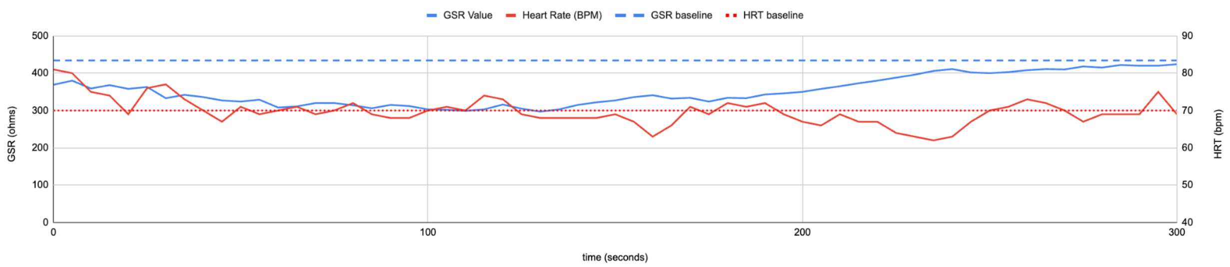

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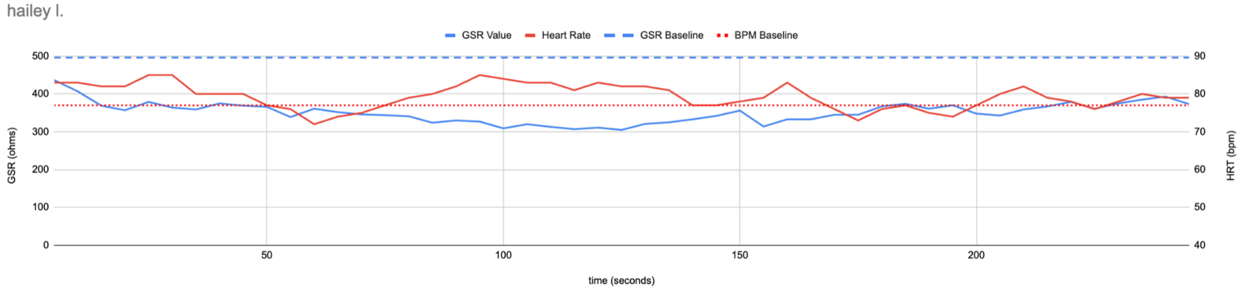

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