Impact on Colored LED Stimuli on Stress Responses in College Students

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Abstract

A study on how various colors can affect certain stimuli provides insight on intentionally designing certain environments to either augment or attenuate those stimuli. Galvanic skin response (GSR) is a means to quantify emotional arousal through detecting the change in sweat gland activity and is measured in the form of skin resistance[4]. Arousal is detected when skin conductance increases, or when there is a sharp decrease in skin resistance measured from two electrodes attached to the skin[4]. College student subjects ($n = 23$) were placed in a dark environment and were shown three colors (red, blue, yellow) while measuring skin resistance from a GSR sensor to determine how the three colors change the effect of a stress stimulus presented to the subjects in the form of a clap. Subjects were presented with each color for ten seconds, and the stress stimulus was presented randomly in each of the ten seconds. The study showed that the greatest average percent change in stress stimulus was when the subjects observed red (+6.43%). Paired, one-tailed, T-tests were used to determine the statistical significance of our results, comparing our data for each color against the control (subject saw no color and stress stimulus was presented). The p-values for blue, red, and yellow were $p = 0.18$, 0.0004, 0.43 respectively, and with a confidence interval of 95% ($\alpha = 0.05$), it can be concluded that the color red will increase the intensity of an external stimulus.

Introduction

Past research has shown the effect that color type and intensity can have on physiological responses for emotions and heart rate, but the effect on stress response was not explored[1]. The goal of this experiment was to explore the effect of color on stress through the measurement of galvanic skin response, or GSR. GSR measures the conductivity of the skin's sweat produced by glands with their bases in the subcutis that extend through the dermis to the epidermis[2]. The sensor can be created from a simple circuit, which is then attached to the subject with gel electrodes.

When a stressful event occurs, sweat glands are activated by the release of stress hormones as part of the fight-or-flight response[3]. Essentially, the GSR sensor measures the sudden drop in resistance when the sweat (filled with polar water molecules and salts) appears on the surface of the skin. Typically, these small amounts are too small to be noticed by the human eye but register clearly with use of a sensor like the GSR. More specifically, this experiment examines the average percent change in GSR, as it can be used to measure stress response from different individuals in a comparable manner to determine statistical significance.

For statistical analysis, the null hypothesis is that the difference in mean percent change in GSR for each color (red, blue, yellow) will be zero when compared to no color. To reject, the result would need to indicate that the presence of a color altered the stress response enough for it to be statistically significant.

Methods and Materials

The team acquired an array of materials to create a device that measures GSR in response to changing colors from LEDs, as seen in Figure 1. Lab googles were blacked out with black tape and two holes were open to the sides where RGB LED's were fixed. In the build module, the built device was shown to work similarly to the store-bought device, as seen in Figure 2. In creating

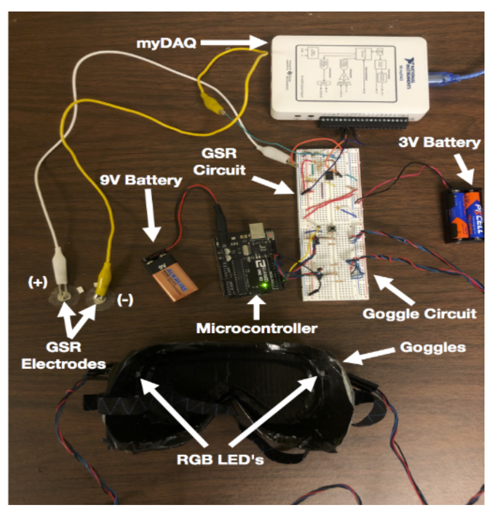

Figure 1: Materials Used in Experimentation

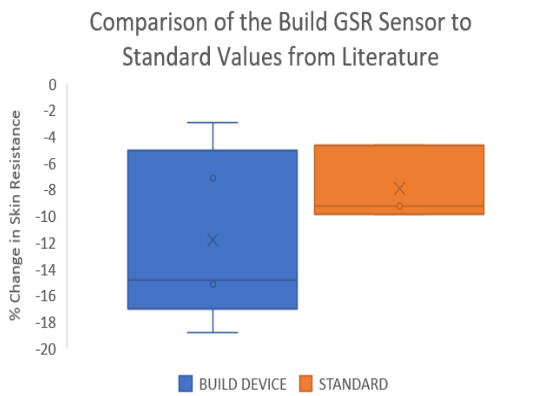

Figure 2: Skin resistance response testing comparing values recorded from build galvanic skin response (GSR) sensor and literature standards on GSR. Comparison of the average % change (Dep. Var.) due to randomized auditory stimuli (Ind. Var), (n = 1 with 5 trials). Two-tailed, two-sample with equal variance T-test done with α = 0.05. *p* = 0.379.

the built device, the team had to assemble a circuit, feed the GSR signal from the electrodes through the circuit and into the myDAQ for data acquisition. Once the device was built, the study procedure was created. According to an *a Priori* power analysis done in G*, the study required a testing population of twenty-three people (n = 23), so twenty-three undergraduate students were recruited as participants. The procedure, which is represented in Figure 3, was as follows: First, the testing goggles were put on the participant and the electrodes were connected to the palmar side of the middle and index fingers on the non-dominant hand. Once the testing started, the subject would be exposed to darkness for ten seconds. Then, the participant would be exposed to one of the chosen colors (either red, blue, or yellow) for ten seconds. Afterwards, the subject would be exposed to darkness again for ten seconds. Then, the subject would be exposed to one of the two unused colors for ten seconds. The subject would experience another ten second period of exposure to darkness, and the ten-second exposure to the remaining color would follow. The procedure ends with a final ten seconds without any

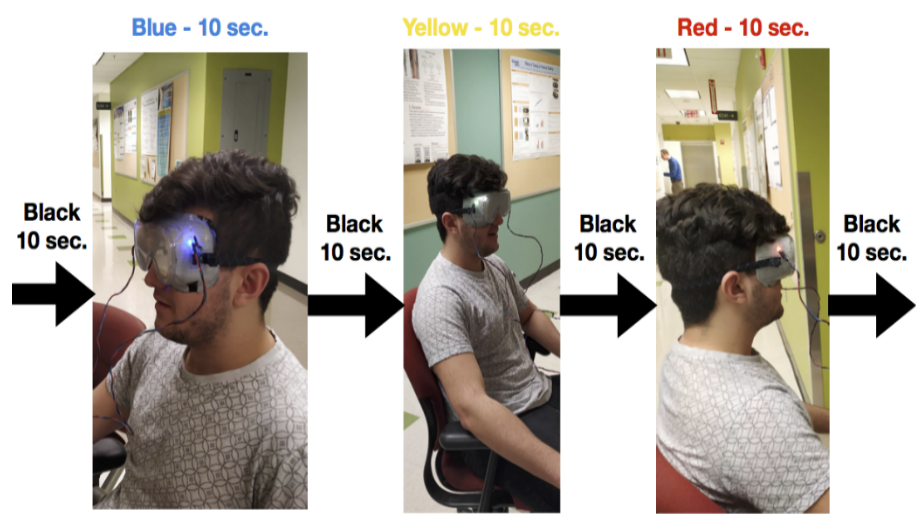

Figure 2: Testing Procedure Flowchart

color. For the 10 second periods with color and the final darkness period, a noise stimulus (a clap) was administered at a random point chosen by the experimenter. This was imposed to see the response to external stimuli in the presence of different lighting conditions. In Figure 4, an example of the raw data acquired from the built device and circuit is presented.

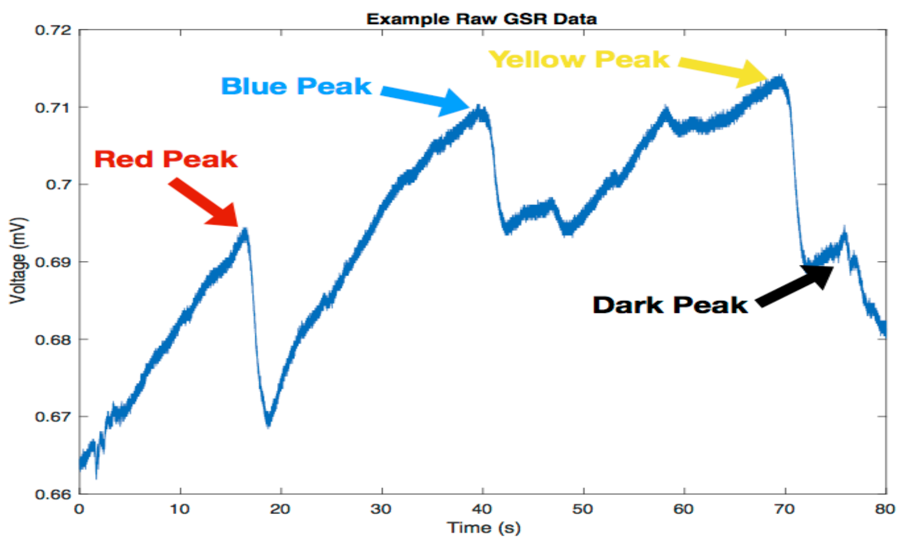

Figure 3: Example of Raw Data Collected from GSR Device

Results

The average percent change for each color was calculated (Fig. 5), and it can be observed that red light had the greatest percent change in GSR when subjects were introduced to a stress stimulus.

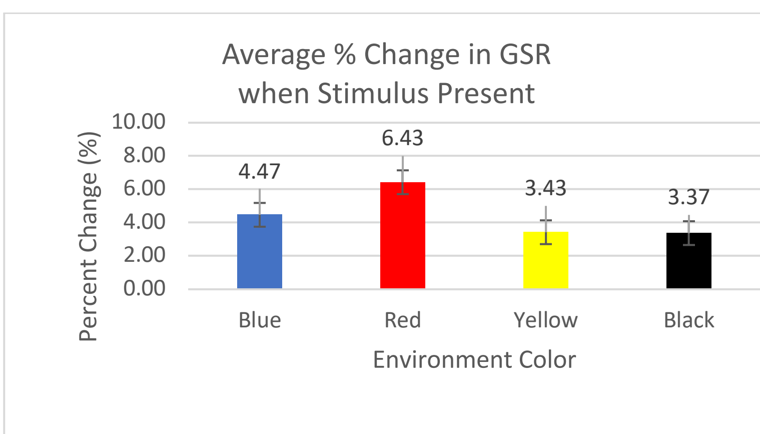

Figure 5: Comparison of average % change (dependent variable) in GSR stimulus for each environment color (independent variable), (n = 23), (Paired T-Test, , from left to right: *p = 0.18, 0.0004, 0.43*, α = 0.05).

A paired, one-tailed T-Test was done, comparing each subjects' average GSR for each color to their response when no color was present (the control, which is the dark peak).

	Blue	**Red**	**Yellow**	**Black**
Avg. % Change	4.47 %	6.43 %	3.43 %	3.37%
STD	0.06	0.04	0.02	0.02
t-value	0.90	3.81	0.18	N/A
p-value	0.18	0.0004	0.43	N/A

Table 1. Descriptive statistic, standard deviation, Paired T-Test test statistic, and p-value for each color environment

The p-values for comparison of black to blue, red, and yellow were p = 0.18, 0.0004, and 0.43, respectively. With a 95% confidence interval ($\alpha = 0.05$), the null hypothesis stating that the difference in means will be zero can be rejected for the red environment, as $p < \alpha$. This implies that there is statistical significance for the increase in GSR when subjects were introduced to the color red. However, both blue and yellow environments had a p-value greater than α, which means that we failed to reject the null hypothesis for those two environment colors.

Discussion

Based on previous literature, there was an expected change that different colors would cause an effect on human physiology[1]. This study took this literature one step forward and assessed the specific effects on electrodermal activity. It was concluded that the presence of any visual stimulus increased the body's stress response, regardless of what color. However, red light had an increased percent change of electrodermal activity markedly above the other two colors and the darkness control condition. The lowest percent change in GSR was present when no light stimulus was applied (i.e. darkness). As shown by comparing our p values to the confidence interval of $\propto = 0.05$, the red stimulus had a significant impact and allowed us to reject the null hypothesis; however, we failed to reject the null hypotheses for both the blue and yellow lights because their p values were greater than $\propto$.

Even though the best was done to create meaningful results, a possibility of error is always there. Possible errors fall into two categories: hardware and design. Hardware errors include the possibility of the device not totally blocking out all light or being fitted incorrectly on the subject, the circuit not working or providing incorrect values, or using LEDs that were not powerful enough to exert a similar effect on the eye when the experiment was under way.

Design errors probably stemmed from non-consistent auditory stimuli, as sometimes the clap that was administered was not the best, and it would be slightly quieter than others. Something to do in future studies is standardize the noise by creating an audio file and giving the participants headphones so that the stimulus is standardized for all subjects.

Furthermore, future work related to this study could include observing the stress response under more common lighting conditions (e.g. sunlight, artificial lights that cast more warm orange shades or colder blue shades). There was minimal exploration of that topic in the literature surveyed. Additionally, light intensity could be considered to examine possible thresholds of stress responses.

Conclusion

A GSR reading can be a strong indicator of a physiological stress response due to a presented stimulus. This response can be modified by presenting the subject in different colored environments. Our results found that only one of the colors had a statistically significant impact on the subjects' stress responses, with a 95% confidence interval. This allowed us to reject the null hypothesis for red but not for any of the other colors. As noted in the discussion, there were a few areas that can be improved that may have caused this failure to reject the null hypothesis for the other colors. If this experiment were to be recreated, it would be beneficial to standardize the audio stimuli for each subject. Furthermore, lighting shade and intensity should be considered as a focus to expand upon in future work. While further study is needed, the implications of the experiment are manifold – being able to condition the body's stress response has many applications for strategically increasing or decreasing stress in specific scenarios. For example, studying under a certain light could keep you calm and focused, while playing a sport under a different light could increase your adrenaline and help decrease response time using one's physiological response to their advantage.

References:

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