It's Not Easy Being Green?

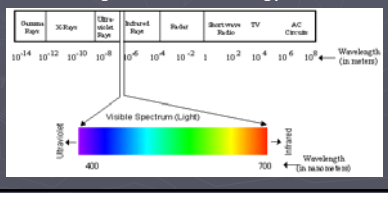
A Science Seminar Project By Max Rosen-Long

Introduction I

- When Kermit the Frog declared "It isn't easy being green," he wasn't discussing the scientific effects of color.
- However, color is an important, but often under appreciated, aspect of everyday life that effects our bodies in different ways. Color perception allows us to differentiate between a red and green light, to read the text on a colorful sign, or to appreciate a beautiful painting.
- What humans see as color is really the reflection of certain frequencies of light off an object and into the eyes, which our eyes capture and turn into color.

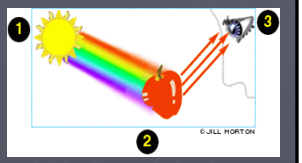
Introduction II

- Color (and all vision) is created by electromagnetic waves with wavelengths of 390-750 nanometers (This is the visible light spectrum).
- Waves with longer wavelengths (such as red) have lower frequencies, and therefore exhibit less energy than short wavelength waves (like purple or blue), which have high frequencies and high amounts of energy.



Introduction III

- The eye absorbs light to give us the perception of color. Light enters through the cornea and the iris, and then hits the retina. On the retina are millions of rods and cones; light sensitive nerve cells called photoreceptors. Rods respond to the intensity of light, and cones respond to color (specifically the primary colors of light: red, green, and blue).



Hypothesis

- In addition to the physical properties of color (such as wave energy), there are also cultural and emotional connotations. Do these psychological experiences of color have any correlation to it's physical effects? For that matter, what *are* the physical effects of color? Specifically, what are its effects on heart rate (pulse) and blood pressure?

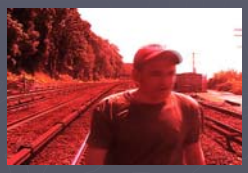
Methods I

- To test the effects of different colors, subjects were shown a 3 minute video in four different colors: normal (as a control), red, green, and blue.
- Heart rate and blood pressure were taken before and after each video. Between videos was a re-calibration period in which the subjects closed their eyes for 3 minutes.
- The percentage change (% Δ) in these factors was measured and graphed. This allowed for differences in the individual subjects' heart rates and blood pressures to not affect the results.

Methods II

- Below are examples of the colored videos used:

Control: All Colors



Video I: Red (750 nm)

Methods III

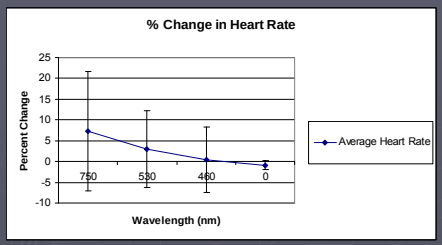
Video III: Green (530 nm)

Video IV: Blue (460 nm)

Methods IV

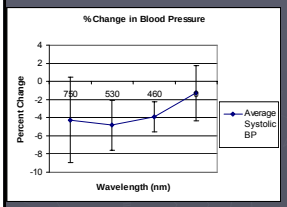
- To test the validity of the data gathered, a second experiment was conducted. Subjects were shown the control video (all colors) four times.
- The purpose of this additional experiment was to observe whether the original experiment was controlled properly. If it had been controlled properly, the only effects would be caused by the different colored versions of the film. If it had not been controlled, other variables would affect the heart rate and blood pressure.
- The second experiment, run in the same conditions as the first, and using the same procedures, showed the effects of other influences on sitting and watching The Waterline without the different colored versions.

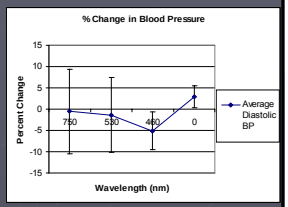
Results I



Change in Heart Rate in Response to Different Color Wavelengths
As wave energy increases, the amount of change becomes increasingly similar (i.e., the amount of variation for red (750) is larger than that of green (530), which is larger than that of blue (460)).

Results, II

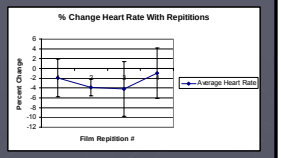




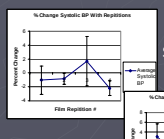
Change in Blood Pressure in Response to Different Color Wavelengths
The above graphs display the percentage change in heart rate (systolic pressure/diastolic pressure) as wavelength decreases and wave energy increases. The systolic pressure shows an increasing trend as energy increase, whereas the diastolic pressure shows an overall decrease, then a sudden rise as color return to normal at 0 (all colors).

Results III

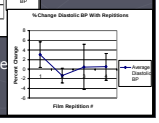
Results of controlling experiment:
the percentage of change observed when the control video (with all colors) was repeated four times: Four trials, or repetitions (because each trial showed the same video), were run for each subject, and numbered as 1 through 4.



- Some change in heart rate was observed, showing that outside influences had an effect on the heart rate.
- Blood pressure also changed due to outside influences. This can be seen in that the video was the same in each repetition, yet blood pressure changed. There is no trend that can be observed, as the outside influences changed at each trial.



Systolic Pressure



Diastolic Pressure

Conclusions I

- The overall trend that can be observed in all of the above results is that lower wavelengths of light have a larger effect on heart rate and blood pressure (i.e., red more than green, green more than blue, blue more than the control).
- In addition, lower wavelengths have more variety of change (as can be seen in larger error bars) than higher wavelengths.
- This fits into the cultural constructs that exist for these colors: red is supposed to be the color of anger and strong emotions. If red has the largest effect on the body of any colors, it makes sense that red would be the color of strong emotions (such as anger). Blue is known as a calming, relaxing color, and even sometimes a sad one (such as Picasso's *blue series*). According to the experiment, blue has very little effect on the body, which fits with the cultural connotation of sadness and relaxation.

Conclusions II

Pablo Picasso, *Woman With Crossed Arms*

- Color's effects on heart rate showed a clearer trend than those of blood pressure. Systolic blood pressure showed a decrease in change as wavelength decreased though, and the error bars also decreased as wavelength increased. Diastolic blood pressure was less clear; the amount of change *increased* as wavelength decreased. However, for the control the percentage of change decreased again.
- It can be observed from this that our eyes are used to seeing all colors together; in each control the percentage of change was very small, and the error bars also.

Conclusions III

- The second experiment served the purpose of showing whether the experiment was controlled properly. However, showed that there were outside influences that affected the results; and therefore that it was not controlled properly.
- Both heart rate and blood pressure showed changes caused by outside influences. These increases were caused, in both cases, by a flurry of motion in the room where the experiment was being conducted. These changes showed that these outside influences had an effect.
- Heart Rate, seen in figure 4, shows less dramatic changes. This makes it a more reliable indicator for the experiment, because outside influences had less effect on it.
- In effect, Kermit wasn't entirely wrong; it's easier to be blue than it is to be green, but it's even harder to be red.

Future Studies

- In the future, this experiment can be run in completely controlled conditions. Subjects would sit alone in a dark room while they watched each film, and would have a much larger calibration period between each version (each version could even be shown on an entirely different day). More subjects could be tested also. Better, more precise instruments could be used.
- With more resources, this experiment could be changed to measure the effects of color on the parts that are affected most (namely, the brain). Functional Magnetic Resonance Imaging (fMRI) could be used to measure the brains response to different colors. Using fMRI scans, it could be seen whether the parts of the brain which respond to color also affect other parts of the brain.