Over the years, multiple studies that have found a significant connection between color and emotion. These studies tend to focus on how a single color shown at a time impacts one's overall mood (see for example, Albert, 2007; Wilms & Oberfeld, 2018). In contrast, there are relatively few studies that examine this relationship in a complex setting.

Kaya and Epps (2004) conducted a study to find a connection between the emotional associations of college students and specific colors. To find a connection of emotional associations and various colors, they used the Munsell color system. They used three different color categories which included principal hues (red, purple, etc.), intermediate hues (red-purple, yellow-red, etc.), and achromatic hues (black, grey, white). The study was conducted by showing participants a computer screen with a single color and a natural background. When a participant was shown a color, they were asked what emotional response they felt. Participants could only give one emotional response per color shown. Kaya and Epps (2004) created three different categories to sort out the emotional responses they received. The categories are positive emotions, negative emotion, and no emotion.

Kaya and Epps' (2004) study resulted in finding a connection between college students associating strong emotions with specific colors due to past encounters with those specific colors. They found colors like blue, yellow, and green elicited positive emotional responses from participants. These colors invoked feelings of relaxation, happiness, and comfort in participants while red invoked both positive and negative responses. Red had many different associations such as love, blood, and evil (Kaya & Epps, 2004). While the results were helpful to show a relationship between color and emotions, the process for sorting emotional responses gives a very limited concept of the emotional association of the various colors shown and does not account for the participant's emotional intensity.

The study conducted by Wilms and Oberfeld (2018) took a different approach by changing a color's hue, brightness, and saturation to see the impact it has on one's emotional and physiological response. They measured participants' emotional response using a nonverbal Self-Assessment Manikin (SAM) scale (Lang as cited in Wilms & Oberfeld, 2018). The SAM scale has five pictograms with labels to display both valence and arousal to participants. For valence, the scale started with a happy, smiling face and progressed to an unhappy, frowning face. For arousal, the scale started with a relaxed face and progressed to a happy face. The researchers then measured a participants' skin conductance and heart rate to measure their physiological response. Wilms and Oberfeld (2018) displayed chromatic colors (green, red, and blue) on a wall using an LED light in a dark room for participants to view. They only showed a single color at one time. Wilms and Oberfeld (2018) found a significant effect in arousal when looking at the group of chromatic colors. They noted how many studies did not manipulate multiple variables when trying to find the relationship between color and emotion. While Wilms and Oberfeld (2018) were trying to identify a relationship between color, emotion, and physiological reactions this literature gives insight on how manipulating multiple variables can change the impact of emotions when viewing color.

Terwogt and Hoeksma (1995) administered a study to find the link between color preference and emotion. They presented different aged groups (7-year-olds, 11-year-olds, adults) with six color cards (red, blue, yellow, green, black, white) and six emotion cards (anger, happiness, sadness, fear, surprise, disgust) that were randomly read aloud one at a time. Participants were asked to pick a color that best fits the emotion read. Terwogt and Hoeksma (1995) found colors are linked to specific emotions and even differ between the different aged groups. For the younger aged groups, yellow and red were linked to positive

emotions. While for the adult group, blue, red, and green were linked to positive emotions and yellow was rated as less preferred.

Another study done by Valdez and Mehrabian (1994) examined how different wavelength colors can influence different dimensions of emotions. The researchers used the Pleasure-Arousal-Dominance emotion model (Mehrabian & Russel as cited in Valdez & Mehrabian, 1994) to analyze the influence of hues, saturation, and brightness. The first dimension, pleasure, measures one's feeling of pleasure or displeasure towards something. The second dimensions, arousal, measures one's feeling of excitement or calmness. While the third dimension, dominance, measures one's feelings of dominant or submissive emotions. Out of all of Valdez and Mehrabian (1994)'s results, the most interesting finding showed that the darker and more saturated a color is, the higher the participants rated the arousal for that color. All their results suggested highly saturated colors were rated the highest in any of the dimension of the model.

Mammarella et al. (2016) suggested the concept that certain colored words are tied to specific emotional associations (positive, negative, or neutral) and this would in turn influence a participants' memory recall. In this study, they decided to test different age groups to see if it played a part in the impact of people's memory recall with emotional associations. There were two age groups, younger adults (18-25 years old) and older adults (65-80 years old). Each participant was shown one word at a time that was colored differently (green, red, or blue). These words either had a positive emotional association (green), negative emotional association (red), or neutral emotional association (blue). After the participant viewed all the words for each color, they were given a list and asked to give a yes or no response on if the words that were shown (Mammarella et al., 2016). They in fact did find a difference between age groups and the responses of emotional associations. They found young adults remembered negative emotional associations (red) words better than positive emotional associations (green) words. While older adults remembered positive emotional associations words (green) better than negative emotional associations words (red) and neutral emotional associations words (blue). Mammarella et al.'s (2016) use of different colored words could give insight into how participants associate different colors emotionally. Those associations could impact participants' emotional responses when viewing multiple colors together.

Hupka et al. (1997), conducted a similar experiment about word association and colors. They were trying to find the connection between if a word, emotion, was associated with certain colors. Participants were asked to rate on a 6-point scale to what extent prelisted emotions (anger, envy, fear, jealously) reminded them of prelisted colors (black, blue, brown, gray, green, orange, pink, purple, red, violent, white, yellow). This was conducted as a cross-cultural study and included participants in the United States, Germany, Mexico, Poland, and Russia. Since this was a cross-cultural study, all tests had to be translated into different languages. Although there was a little variation in color and emotional association due to cultural differences, there was a correlation between these colors and emotions. The results showed for emotions such as anger, all nations rated black the highest for association. The same results were found for fear minus one nation that rated red the highest for this association (Hupka et al., 1997).

There were a few studies that used different scales or categorization methods for emotional responses. Studies such as Wilms and Oberfeld (2018) used a nonverbal scale (SAM) to help measure emotional valence and arousal while Valdez and Mehrabian (1994)

used a three-dimensional emotion model to measure participants' emotional responses. Those studies used a type of emotional scale to record responses when Hupka et al. (1997) opted to use a normal rating scale to measure these emotional responses; this differed from Kaya and Epps (2004) who did not rate emotions on a scale but instead categorized the emotions associations. Mammarella et al. (2016) and Terwogt and Hoeksma (1995) both stayed away from using scales altogether and measured the emotional responses or memory recall through different methods.

All these studies were conducted to find some form of connection between color and emotions. These studies all presented the colors individually to the participants, some with slight modifications to the colors, to find the participants' emotional response. These studies are all limited by showing colors in isolation instead of presenting them in combination with other colors. My study is an expansion to the other studies because it examined how multiple colors can impact one's emotions. It can also contribute to how spaces are decorated to make them have a more positive atmosphere overall. My study is an online study that will ask participants to rate their emotions on a rating scale while viewing two different color schemes with various saturation levels.

I hypothesized there will be a difference in emotional responses between primary color and secondary color combinations. I also hypothesized colors presented with a higher saturation will have the greater positive emotional response.

Method

Participants

A total of 87 participants took my survey. I recruited my participants from social media platforms (Twitter, Instagram, Reddit) and the Lindenwood Participant Pool (LPP). The LPP uses Sona Systems as a way for Lindenwood researchers to recruit student participants from Lindenwood courses. Those who participated from social media were not compensated for their completion of the survey, while those in the LPP were compensated with extra credit points for their participating LPP course.

Of those 87 respondents, not all participants answered all the demographic questions. There were 54 of participants who identified as female (62.1%), 17 who identified as male (19.5%), 1 who identified as other (1.1%), and 1 preferred not to say (1.1%). For age, 66 people identified as 18-25 years old (75.9%), 4 people identified as 26-33 years old (4.6%), and 3 people identified as 34-68 years old (3.4%). For cultural identity, I did a content analysis and made categories for the answers given. There were 28 Americans (32%), 5 Europeans (5.7%), and 20 selected Other (23%).

Materials and Procedure

I created a survey using Qualtrics to test my hypotheses. The survey included an informed consent edited from a template created by the Institutional Review Board at Lindenwood University. It included a summary of the tasks the participant will be asked to complete, risks and benefits associated with the study, compensation of extra credit points for participants in the LPP, confidentially of the participant's data, and the researcher's contact information.

The survey included two sets of questions; the initial questions contained six identical images that differed in color scheme and saturation. Three of the images were colored using primary colors (red, yellow, and blue) while the other three were colored using secondary colors (orange, green, and purple). These images were created using the application NotesWriter Pro (Kairoos Solutions SL, 2021). They were drawn and duplicated to follow

either the primary or secondary color scheme. Each image in a color scheme had a different saturation percent (-50%, 0%, 50%). To create the various levels saturation, the application Apple Photos was used (Apple Inc, 2021). When all images were calibrated with the correct saturation, they were uploaded into Qualtrics (refer to the Appendix to see the six images used). In the survey, each participant was shown each image in a random order to account for counterbalancing and each of the images were followed by a slide scale. The scale was for participants to rate the intensity of prelisted emotions, from 0 (*no emotional intensity*) to 10 (*strong emotional intensity*). It included a free-response question if the participant felt they wanted to expand on their answers. For each image, I grouped all the data about emotions into positive and negative categories to compute the emotional intensity. After this was done, I took the average of each participant's scores for emotional intensity. After these questions there was a set of demographic questions that asked the gender, age, and culture the participants identify with.

Following these sets of questions was a debriefing statement thanking the participants, informing them of the main purpose of the study, and restating how their information will be handled carefully and kept confidential. It also included the researcher's contact information again, in case the participant had any questions about the survey.

When the survey was completed, I uploaded the survey link to Twitter, Instagram, Reddit, and Sona Systems. For the results, I used IBM SPSS Statistics (Version 28) to analyze the responses from the survey.

Results

To test my first two hypotheses that there will be a difference in emotional intensity response based on color scheme and saturation, I conducted a 2 (color scheme) x 3 (saturation) repeated measures analysis of variance (ANOVA) for the intensity of negative and positive emotions separately.

The results of a 2 (color scheme) x 3 (saturation) repeated measures ANOVA conducted on negative emotions revealed a statistically significant main effect of color scheme, $F(1,86) = 25.83$, $p < .001$, $\eta^2 = 0.23$ and a statistically significant main effect of saturation, $F(2,172) = 8.45$, $p < .001$, $\eta^2 = 0.09$ for negative emotions. The interaction between color scheme and saturation was not statistically significant. The results of a post-hoc analysis revealed that the primary color scheme ($M = 7.22$, $SD = 5.58$) elicited more intense negative emotion than the secondary color scheme ($M = 4.28$, $SD = 4.75$), $t(86) = 5.08$, $p < .001$, $d = 0.55$. Post-hoc tests conducted to determine where the differences were among the three saturation levels revealed a statistically significant difference between the positive 50% saturation ($M = 3.17$, $SD = 3.46$) and negative 50% saturation ($M = 4.72$, $SD = 4.24$) levels, $t(86) = -3.69$, $p < .001$, $d = .40$ where the negative 50% saturation level elicited significantly more negative emotion than positive 50% saturation level.

A 2 (color scheme) x 3 (saturation) repeated measures ANOVA conducted on positive emotions revealed a statistically significant main effect of color scheme, $F(1,86) = 28.05$, $p < .001$, $\eta^2 = 0.25$ and a statistically significant main effect of saturation, $F(2,172) = 8.51$, $p < .001$, $\eta^2 = 0.09$. The interaction between color scheme and saturation was not statistically significant. The results of a post-hoc analysis revealed that the primary color scheme ($M = 5.11$, $SD = 4.78$) elicited less intense positive emotions than the secondary color scheme ($M = 8.52$, $SD = 6.39$), $t(86) = 5.30$, $p < .001$, $d = 0.57$ and the difference between positive 50% ($M = 3.17$, $SD = 3.46$) and negative 50% ($M = 4.72$, $SD = 4.24$) saturation levels was statistically significant $t(86) = 3.86$, $p < .001$, $d = .37$. There was also a

difference between negative 50% (M = 3.78, SD = 3.77) and 0% (M = 4.64, SD = 3.66) saturation levels, $t(86) = -2.56$, $p = 0.012$, $d = .28$. These results taken together reveal that emotional response does depend on color scheme and saturation, but not the combination of both.

Discussion

My results found there was a connection between emotional response depending on color scheme and saturation but this does not depend on the combination of both. My results indicated that primary color scheme elicited more negative emotions while secondary color elicited more positive emotions. The results also found that -50% saturation evoked more negative emotions than the 50% saturation in participants responses. When looking at Valdez and Mehrabian (1994)'s research, they found similar results about saturation levels. They found the more saturated a color is the higher the positive emotional response will be which is supported by my results.

There were a few limitations for my study, the first being the quality of the images. Since this study was conducted online, the images participants were displayed with were not all the same because of the devices they viewed the images on. For example, a participant could have changed the color temperature on their device meaning the images were not the exact same as someone who did not change their settings. A suggestion for the image quality would be to conduct the study in-person to ensure all participants are presented with the exact same image quality.

Another limitation of my study was the preconceived notions of my images. I picked peppers for my subject matter, but they already came in certain colors, so many people have an idea of what they should look like which could influence the results. A suggestion would be to pick a subject matter that does not have specific colors already attached to it.

Finally, it would be important to replicate this study using more or different color combinations. This would help to see if there is a pattern between different color combinations and help further color and emotion research.

This research and future research could aid in helping institutions such as schools to create positive spaces for students in hopes to improve motivation and their moods in a school environment. It could also help medical offices to make patients feel more welcome in offices and hopefully reduce negative emotions about medical offices. For example, avoiding the use of a primary color schemes and using a secondary color scheme instead for these spaces.

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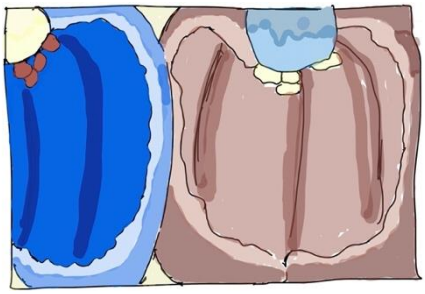
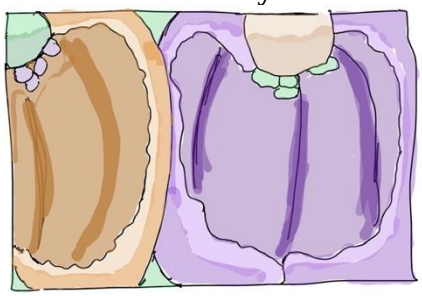
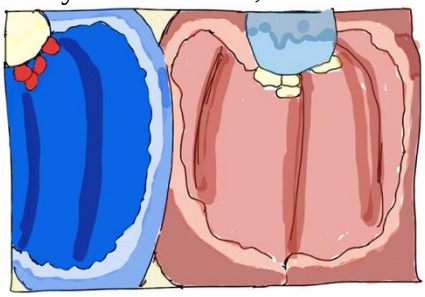
Appendix
Images Used in the Study



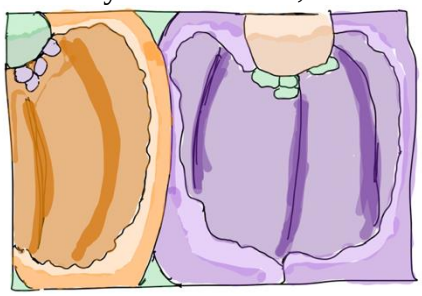
Primary color schema, -50% saturation



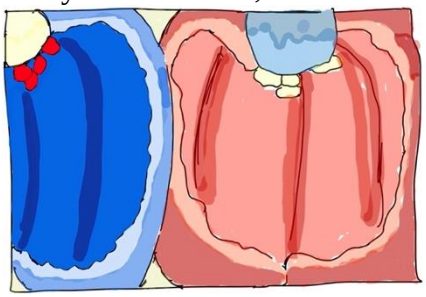
Secondary color schema, -50% saturation



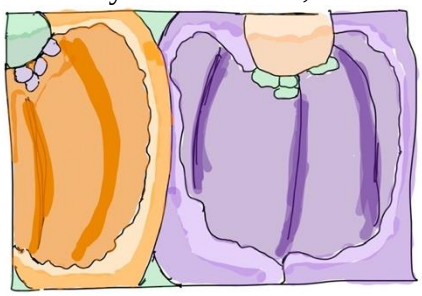
Primary color schema, 0% saturation



Secondary color schema, 0% saturation



Primary color schema, 50% saturation



Secondary color schema, 50% saturation