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The Effects of Colored Surgical Masks on Emotion Recognition and Perception in Adolescents

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Abstract

Since the start of the COVID-19 pandemic, many studies have explored the effects of face masks on emotion recognition, yet no studies were conducted to explore the effect of different colored face masks on emotion recognition. This paper investigated the effect of four colors: red, black, green, and blue, compared to white, on perception of emotional intensity and recognition accuracy. 34 high schoolers were tested through a survey consisting of 120 images of models wearing surgical masks with photoshopped color stimuli. A significant effect was found in the colors red and green. Red enhances the perceived emotional intensity, and green confuses people into thinking the expression is disgust.

Keywords: Emotion Recognition, Colors, Face Masks, Perception

1. Introduction

The ability to read the facial expressions of others is essential to successful social interactions. Humans start to develop their ability to read emotions as young as four months of age (Barbera, et al., 1976). That ability continues to develop from late childhood through adulthood and can be changed depending on the age, gender, and pubertal status of a person (Thomas, et al., 2007; Lawrence, et al., 2015). However, this ability has been affected recently by the SARS-CoV-2 (COVID-19) pandemic. Since the beginning of the COVID-19 pandemic, face masks have been essential to reduce the spread of the virus (Li, et al., 2020). When the pandemic hit many countries around the world, people were required to wear masks outdoors and indoors. Because of this public health need, wearing masks has become a normal part of social interactions for many people. As it has been about 2 years since the World Health Organization (WHO) declared COVID-19 a global pandemic, many types of masks have been sold on the market with various designs and colors.

1.1 Effects of Masking on Emotion Recognition.

Mask wearing habits have a negative impact on the ability to read facial expressions. As the COVID-19 pandemic affected people globally, humans have developed a reliance on masking to prevent the transmission of COVID. The pandemic has also changed humans' ways of processing emotions (Barrick, et al., 2021). In Barrick's study, scientists discovered that people who spent more time around masked faces relied more on the cues from the eyes to assess emotions, even if the person they observed did not wear face masks. However, according to Schurgin's (2014) finding, some regions of the face signal more information for a successful emotion recognition (Schurgin, et al., 2014). This leads to inaccuracies in reading emotions daily as selective facial expressions, such as joy and disgust,

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require more visual information from the mouth region.

Then how do people process emotions that depend on visual cues from the mouth region? When most facial visual information is obscured by a mask, one's intake of visual information becomes limited to the eye region, a region that does not provide sufficient information for an accurate emotional recognition. Carbon (2020) found out that accuracy of facial expression judgment is reduced when looking at masked individuals, except for fearful and neutral faces. In addition, subjects in a similar study of emotional intensity perceived all emotions expressed by masked individuals as less intense (Pazhoohi, et al., 2021).

1.2 Effects of color on emotion recognition

Limiting visual information is not the only factor that affects emotional recognition. Differences in the color of objects in a subject's visual field may play a role in emotion recognition as well. Previous studies have found that facial color, clothing color, and background color can modulate the perception of emotional expression (Minami, et al., 2018; Nakajima, et al., 2017; Wiedemann, et al., 2015). However, these studies only tested three colors in their experiments: red, gray, and blue. Red was found to increase perceived anger and aggression while blue and gray had no effect on emotional recognition (Minami, et al., 2018; Wiedemann, et al., 2015). The potentially synergistic effects of the face masks' colors on emotion recognition have not yet been researched.

The association between color red and emotion is proven to have an impact on facial expression recognition. Therefore, with a mask occluding more than half of one's face, red is more likely to influence humans' perception of an expression as more angry and aggressive. Similar results would potentially be shown in different colors, with direct correlations with their positive or negative emotional associations. Furthermore, influenced by the mask color, misinterpretations of an emotion would be more likely to occur, causing inaccuracies during the emotion recognition process. With that in mind, this study aims to investigate the effects of colored surgical masks on the ability to accurately recognize emotions and emotional intensity.

2. Method

In this project, data was gathered in-person, through a Qualtrics form based on similar methodology done by Pazhoohi (2021).

2.2 Participants

A total of 34 subjects participated in this study. All participants were high-school students (17 men, 16 women, and 1 preferred not to say) between 14 to 18 years of age. All participants were students at a boarding school in Eastern Virginia. Exclusion criteria included diagnoses of color blindness, autism, Asperger's, and Alexithymia, as self-reported at the beginning of the experiment. 17 of the participants self-identified as White, 6 Asian, 6 Black, 4 Latinos, and 1 Turkish. All participants provided written informed consent and participants in the experiment received academic credit and were entered in a raffle for a $20 Amazon gift card. The study was approved by the Christchurch School (CCS) internal review board.

2.3 Stimuli

A total of 120 images were viewed by each participant. The images consisted of expressive faces posed by 2 female Caucasian adults and 2 male Caucasians adults taken from the FACES database (Ebner, et al., 2010). Each model provided six facial expressions: happiness, fear, anger, disgust, sadness, and neutrality. Surgical masks were photoshopped into the pictures using Adobe Photoshop, with 5 color stimuli in total: White, Black, Pure Blue #0025ff, Vivid Red #e20410, Strong Yellow (soft green) #a2bc00 (Figure 1). Faces with white masks are considered as the control group as white is the absence of color. Black, blue, and red were chosen according to a study that tested the effect of background color on facial expression perception (Minami, et al., 2018). The color green, however, was chosen based on its association with positive and powerful emotions such as relaxation and fear

(Jonauskaite, et al., 2020; Jonauskaite, et al., 2019).

Figure 1. Examples of masked facial expressions in order of anger, neutral, joy, disgust, and surprise. The original images were obtained from the MPI FACES database.

2.4 Procedure

Before beginning the experiment, participants were taken to a quiet room in the school's science building. They were given a consent form to fill out and had their phones taken away. Collecting phones before starting the experiment was deemed necessary to maximize participant engagement during the study. Participants had the option to bring their own computer or use the one given to do the survey. The study was conducted in person to allow the researcher to monitor engagement and maintain a low distraction environment.

In the survey, each individual was shown randomly ordered images of various masked people making different facial expressions. Under each image, participants were asked to answer the following questions:

1. "What is the facial expression of this person?" Their choices were: anger, disgust, fear, happy, neutral, fear and sadness.
2. "From 0 to 100%, how much of this emotion is the person expressing?" with a provided scale to interact. The question of expressive intensity was not asked for faces that were judged to be neutral.

Other than experimental questions, participants were also asked about demographic information such as their race, age, sex, and whether they meet the exclusionary criteria. The language used in this study was written at an appropriate level for students at an English-speaking school to understand. The experiment was conducted across a time span of two weeks.

2.4 Data processing and analysis methods

The data collected was analyzed using three statistical tests, the two-way ANOVA, Chi-squared, and *t*-test. Each test has a different objective: A two-way ANOVA test was performed on all colors to determine an overall effect of it on emotional intensity. As previous studies have established a clear effect of red on emotion recognition, an independent *t*-test was used to examine red and white separately. Finally, to determine whether color has an effect on emotion recognition accuracy, a Chi-squared test was conducted. A result is indicated as significant when its p-value is less than 0.05.

3. Results

3.1 Perceived intensity of facial expressions

Average emotional intensity ratings were compared across gender of models, gender of participants, and individually by each emotion. Emotions that were judged to be neutral do not have emotional intensity ratings. These ratings were pooled and compared by color of mask and no statistically significant data was found through two-way ANOVA tests. However, looking at the average emotion intensity ratings of all participants, models, and emotions pooled by color, a trend toward significance was found with a p-value of 0.0601 (Figure 2).

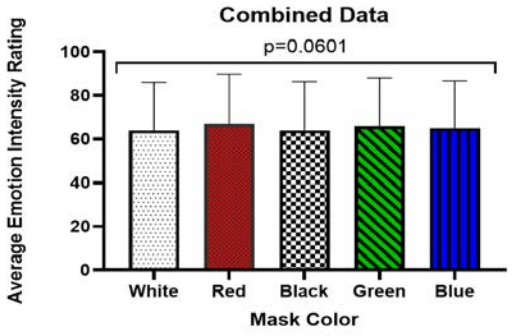

Figure 2. Average intensity of emotions by mask color. Ratings for emotional intensity were collected and averaged among all participants and compared by mask color of models. Data displayed in mean and SD. *p=0.0601* via 2-way ANOVA test.

Intensity ratings from all participants looking at all models were averaged and compared for only white and red masks. The comparison was also performed across gender of models and gender of participant, although no significance was found. However, when looking at the combined ratings, the significant effect of red has on perceived intensity of all expressions was found through an independent t-test with a p-value of 0.0182 (Figure 3).

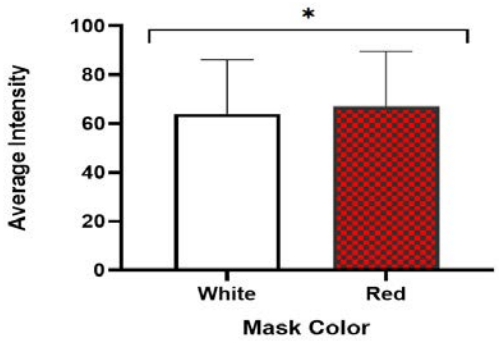

Figure 3. Effect of red on the perception of emotional intensity. Average emotional intensity ratings for all models and participants were compared for red and white masks only. Models wearing red masks received significantly higher emotional intensity ratings compared to the control group (white masks). Data displayed in mean and SD. $p<0.05$ via independent t-test.

3.2 Emotion Recognition Accuracy.

All responses were sorted by color and broken into 5 categories: combined responses, responses from female participants, responses from male participants, responses toward facial expressions posed by female models, and responses toward facial expressions posed by male models. No significant differences were found in responses sorted by either male or female participants. However, results showed a significant effect of all colors on disgusted facial expressions with a noticeable difference between red and green masks ($\chi2=12.9934$, $p<0.5$; Figure 4A). The effect also appeared on disgusted facial expressions posed by both female models ($\chi2=15.2795$, $p<0.005$; Figure 4B) and male models ($\chi2=9.6495$, $p<0.05$; Figure 4C). Another significant effect was found in all participants' responses toward fearful facial expression posed by female models ($\chi2=10.7489$, $p<0.05$; Figure 4D).

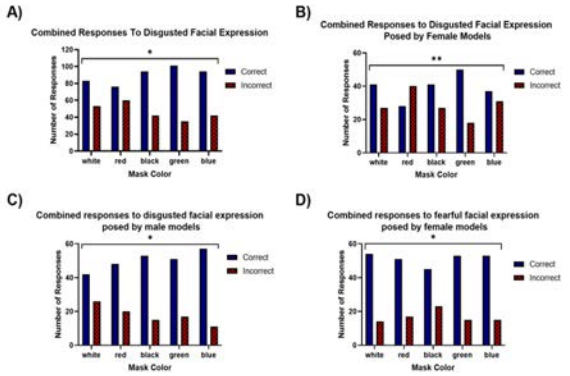

Figure 4. Emotional recognition accuracy by mask color. Correct and incorrect answers were counted and compared across different mask colors. Significant differences were observed in all responses to the disgusted facial expression (A), as well as in isolated responses to both female (B) and male (C) models making a disgusted facial expression. A significant difference was also observed in response to female models making a fearful facial expression (D). * $p < 0.05$, ** $p < 0.005$ via independent Chi-Square test.

4. Discussion and Limitations

In this study, the effect of colored surgical masks on emotion recognition was investigated by comparing all colors (red, black, green, blue) with white. Results showed that red does increase the perceived intensity of all emotions (Figure 3), which supports the previous findings of the color red's effect on clothing (Wiedemann, et al., 2015) and facial expressions (Nakajima, et al., 2017). Though the effect of the red mask on the perception of emotional intensity was found to be significant, results showed that the color only increased the perceived intensity to a small degree (Figure 3). Other than red, no significant effects of color on perceived emotional intensity were found.

Green was discovered to have a great effect on the ability to recognize fear and disgust. Participants' accuracy in recognizing disgusted facial expressions increased when models wore green face masks, whereas red face masks decreased all participants' accuracy in recognizing disgusted facial expressions (Figure 4A). However, this only occurred when the

red face mask was worn by female models. The specific mechanism of this gender-based difference should be explored through further research.

Not only does this investigation contribute to the known effects of red objects on perception of emotions and emotional intensity, but the results also suggest a potential effect of green. The contemporary relevance of these findings is sufficiently justified by the continuing SARS-CoV-2 pandemic. Humans are social beings, we socialize at work, at home, or at play and during this pandemic many people will continue to wear surgical masks daily. However, wearing a surgical mask obstructs parts of a face that are necessary for emotion recognition, and it's clear that mask color may influence the process as well by modulating the perception of emotional intensity and the accuracy of expression recognition. Therefore, the choices of mask color should be taken into consideration as the color chosen could enhance confusion and lead to unsuccessful social interactions.

In summary, red is the only color that increases the perceived intensity of all facial expressions (Fig. 3). The p-value found when testing the effect of all colors on modulation of intensity's perception is close to being statistically significant ($p=0.0601$). The similar study done by Pazhoohi (2021) had a much greater sample size-around 420 participants-compared to this study. If the participant pool were larger, the data may have shown more statistically significant effects of mask color on perception of emotions. Although this study had a limited sample size, several specific effects of mask color were observed. Green was discovered to increase participant's accuracy in the judgment of disgusted facial expressions: Even with its association with positive emotions (Jonauskaite, et al., 2020), participants were more likely to describe an expression as disgusted when the model was wearing a green mask. Green did not appear to affect the accuracy of recognizing emotions such as joy, anger, sadness, and neutral.

One potential limitation to this study is the lack of global diversity of participants. A total of 34 participants were recruited for this study, 6 of which were of Eastern Asian descent. Previous research has found that the interpretation of facial expressions differs across cultures (Rachael, et al., 2009). According to the study, different cultures have different methods of identifying facial expressions: Eastern Asian people primarily fixate on the eye regions, whereas Westerners observe the whole face evenly. A person's method of recognizing facial expressions is uncontrollable, so this might have affected the results.

Additionally, the population pool only consisted of students from one international boarding school. Because of the ongoing pandemic at the time, recruiting participants from other schools was not a feasible task. This limits the accuracy of the result to reflect a larger population.

Finally, if the study only tested 3 colors, as opposed to 6, the result could turn out to be more accurate. Because the total number of face repetition in this study is 6 per expression, the similarity was easily noticed by participants. Moreover, it would reduce the surveying time from 40 minutes to 20 minutes. This helps increase participants' engagement overall.

5. Conclusion

To decrease the transmission rate of respiratory diseases, the practice of wearing masks indoors and outdoors is necessary. The usage of face masks has been shown to influence emotion recognition. According to Carbon (2020), wearing masks makes it harder for people to perceive genuine emotional states. For example, emotions such as disgust were frequently confused with anger. This study investigated the effects of colors on emotion recognition with existing confusion caused by face masks. The results strongly indicate that colors such as red and green affect emotion recognition accuracy. The perception of emotional intensity was also affected by color, specifically when a red surgical mask was worn. Models wearing green face masks were more likely to be accurately categorized as having a disgusted facial expression. Therefore, mask color was proven to be a factor that contributes to social interactions' success. However, the specific mechanisms of these color and gender-based effects need to be investigated through further research in order to be fully understood.

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