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Deciphering Facial Expressions: Factors that Affect Emotion Recognition

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ABSTRACT

Emotional perception is the ability to recognize and identify people's emotional expressions. This study aims to evaluate the accuracy in identification of basic emotions through facial expression, and if the ability to correctly detect emotional expressions is affected by factors such as age, gender, fitness, or education level. We also examined people's ability to correctly identify basic emotions with and without facial coverings, a new normal during the COVID-19 pandemic. Finally, people's ability to identify basic and compound emotions were compared. A google form was used to collect anonymous survey data from 415 participants, which included informed consent, demographic, and face stimuli with various emotional expressions to identify. It was found that basic emotions were easily recognized across all demographic groups. However, faces with facial coverings significantly decreased the participants' ability to identify basic emotions. Compound emotions were more difficult to recognize compared to basic emotions. The influence of age, education, and fitness in the accuracy of recognizing compound emotions varied for each emotion. Some emotions such as Cruelty were better recognized by the 0-20 age group while the 60+ aged participants were more accurate in recognizing emotions like Devastation. Some compound emotions such as Empathy were especially hard to perceive compared to others, suggesting that more cues may be required to identify such emotions. Additional research to elucidate the misclassified compound emotions may help us better understand emotional perception.

1. Introduction

The perception of emotion is a critical component of social interactions (1). Facial expressions along with other body languages are key to how we show and perceive emotions (2, 3). The ability to express one's feelings or intentions through bodily and facial muscular movements crosses cultural and linguistic barriers and is essential for communication (4). When one perceives emotions accurately, they can respond, manage, and adjust emotions to adapt to their environment. If we can understand what people around us are feeling, we could be more in touch with our surroundings (7). With our fast-paced and dynamic lifestyles, this attribute can help us achieve a more understanding and harmonized society. Dr. Paul Ekman constructed and validated an instrument called *Pictures of Facial Affect*, which consisted of 35-mm black-and-white slides of male and female adult faces that were expressing the six basic emotions in 1960 (8). In his seminal research on basic emotions and facial expressions, he proposed seven basic emotions: Fear, Anger, Joy, Sadness, Contempt, Disgust, and Surprise; but later changed to six basic emotions: Fear, Anger, Joy, Sadness, Disgust, and Surprise. He found that individuals of various cultures are highly accurate at identifying the emotional state displayed in facial photographs. Specific facial contortions and movements that are used to express emotional states are universally accepted and understood, although the prescribed meaning of that particular emotion may be culturally distinct (8). The universal nature of facial expressions across cultures strongly supports the idea of the biological roots for this behavior in addition to Darwin's notion that the ability to use and read facial expressions is adaptive (9). In general, investigations of age-related deficits in emotion recognition report a deficit in

the recognition of negative facial expressions (10), including Fear, Anger, and Sadness. Recognizing negative emotions may be generally more difficult as other researchers have also reported finding that positive facial expressions are recognized more quickly than the negative ones (11). The body of research on expression recognition has engendered much confusion regarding the specific deficits observed in emotional processing among the elderly (12). Although there have been inconsistencies across studies, the age-related decline in the accuracy of recognition of negative emotions compared to positive emotions has been consistent (11). Many recent studies have reported higher efficiency of females in detecting emotional expressions (12) as well as children (ages 11-14) showing the near-adult level of sensitivity in detecting basic emotions and most of the complex emotions. Further, with the COVID-19 pandemic that began in 2020, wearing a mask has become a new normal. Although some studies suggest that wearing a mask causes a decrease in a person's ability to perceive facial expressions (13), there is a long-standing debate to understand if facial emotion perception is processed holistically or by individual facial characteristics.

The purpose of the current study was to determine how factors such as age, gender, education, self-reported fitness, as well as facial masks impact individuals' accuracy of correctly identifying basic and compound emotions through facial expressions. The independent variables in the study were demographic factors (Age, Gender, Self-reported Fitness Level, and Education Level), facial factors (basic vs compound emotions, mask vs no mask). The dependent variable in the study was accuracy in identifying basic and compound emotional expressions. We hypothesized that factors such as age, gender, fitness, education level, and facial coverings will each have different effects on the ability to perceive emotion through facial expressions. We expect participants in the younger age group (20-40-year olds), to be more accurate in identifying emotions (14). Further, we expect participants with higher self-reported fitness levels (15) and higher education levels to be more accurate in identifying emotions. Lastly, we expect that facial coverings (masks) will limit the participants' ability to perceive emotions correctly, and basic emotions will be easier to identify compared to compound emotions.

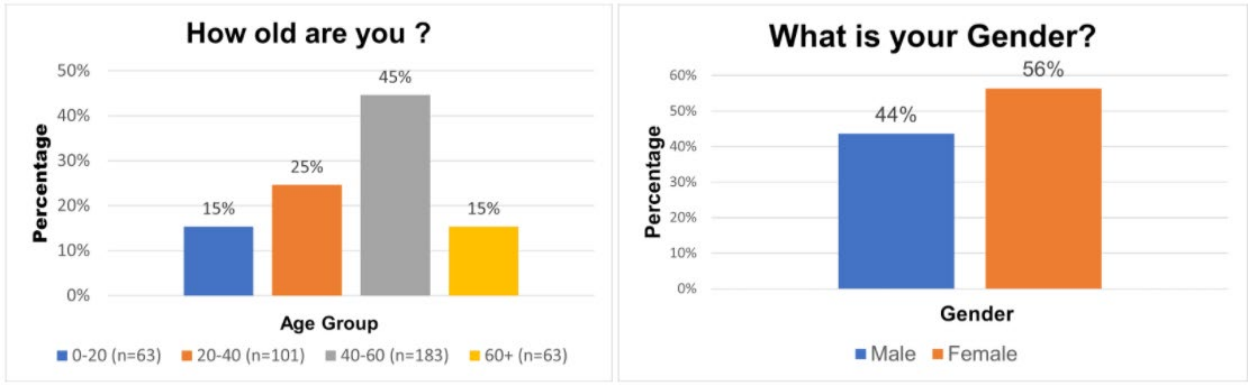
2. Materials and Methods

The study was approved by the school Institutional Review Board (IRB). A Google Form was created to survey the participants anonymously. This survey started with collecting consent from the survey participants as well as demographic information (e.g. age, gender, fitness level, and education level). The survey was distributed to 425 people through various messaging platforms. The results were categorized based on age, gender, self-reported fitness level, education level, and with or without a facial covering.

Statistical Analysis

The data was analyzed using Microsoft Excel and Google Sheets. Pre-survey, the sample size was estimated to achieve the survey results with a statistical confidence level of 95%, i.e. to have an error rate of +/- 5%. Since the response options in this survey was a yes/no, a 50% population proportion was assumed. Power analysis showed a sample size of 385 was required. The current study had 415 survey respondents. T tests and ANOVAs were conducted to examine the accuracy of basic and compound emotion expression recognition was across age, education, fitness level, and gender.

3. Results



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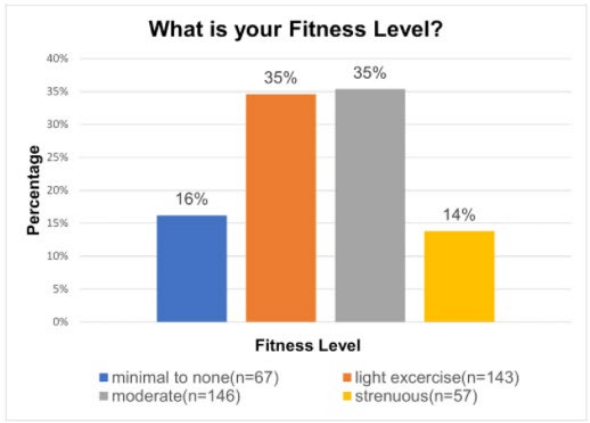

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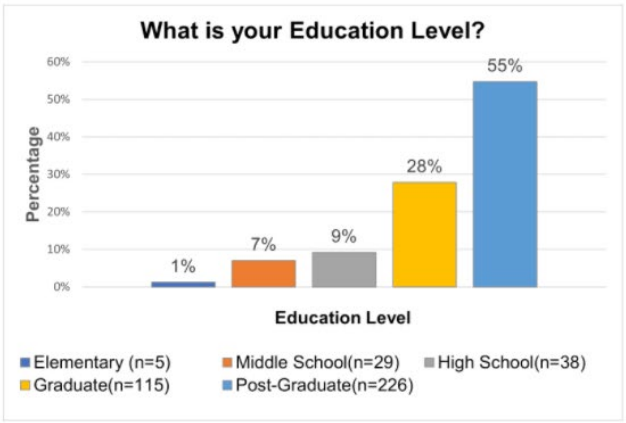

D

Figure 1. Demographic Data of survey participants categorized by age group, gender, fitness level, and education level.

The demographic data of the 415 survey participants is shown in Figure 1 (A-D). There were 181 males and 234 females in this study. The ages were grouped as 0-20, 20-40, 40-60, and 60+. Education level was graded from elementary through post-graduate level education. The self-reported fitness level ranged from minimal to strenuous exercise levels. In this study, people were tested on the accuracy of identifying the basic and compound emotions. The basic emotions Joy, Surprise, Fear, Anger, Disgust, and Sadness (Figure 2A) were tested with and without facial covering (Figure 2B).

Basic emotion recognition

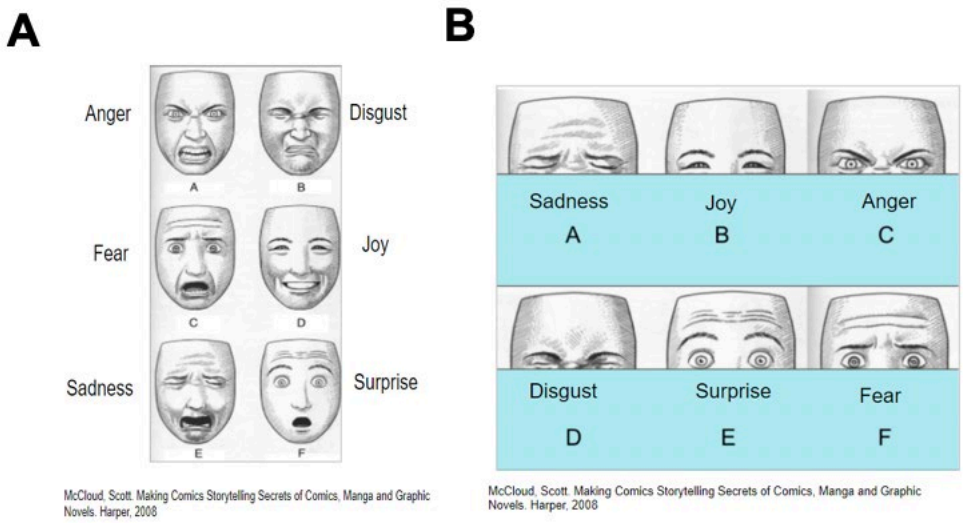

Figure 2. Examples of Basic Emotion (A) and Basic Emotions with facial coverings (B)

First, we examined recognition of the basic emotions. 91% of the participants accurately recognized the basic emotions. The most common errors in the basic emotions were in the identification of Disgust, Surprise, Joy, and Fear. The recognition of basic emotions with a facial covering was 8% lower than without a facial covering (Z = 3.8, p=0.014) in basic emotion recognition accuracy when viewing faces wearing masks compared to fully visible faces.

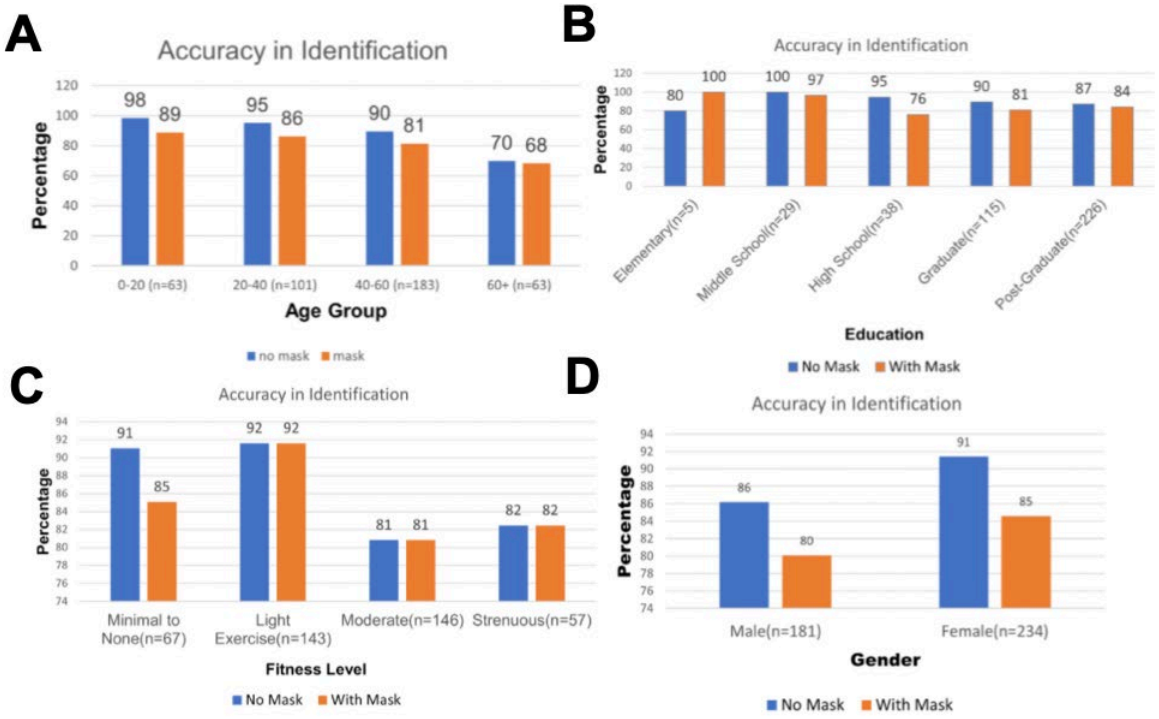

Figure 3. The impact of age, education, fitness, and gender on accuracy in identifying basic emotions with and without masks.

When examining the impacts of age on these effects, we conducted a repeated measures ANOVA and found a significant effect of age [$F(1,398) = 6.65$, $p < .001$], whereas age increased, the ability to accurately identify emotional expression decreased (Figure 3A). We also found a significant effect of the presence of a mask, where performance was worse when the face was masked compared to no mask [$F(1,398) = .015$, $p = .015$]. There was no interaction between mask status and age, although post hoc t-tests suggest the largest differences occurred in the 0-20 and 40-60 age groups ($p < .05$) and a marginal effect in the 20-40 age group ($p = .08$). There was no significant difference in the 60+ age group between mask and no mask conditions. When examining the impact of education on these effects, we conducted a repeated measures ANOVA and found no significant differences across education (Figure 3B). However, when conducting t-tests within each education level, we found that those with High School, Graduate, and Post-Graduate education levels showed significantly worse emotion recognition for masked faces compared to those with no mask (all p's $< .05$). When examining the impact of fitness level on these effects, we found that the accuracy of emotion identification only impacted accuracy if people have minimal to no fitness levels, where accuracy was lower for identifying basic emotions when the mask was present (Figure 3C). When examining the impact of gender on these effects, both men and women were worse at recognizing emotions with a mask on versus no mask [$F(1,398) = 10.91$, $p < .001$]. However, females had a higher accuracy rate in identifying emotions when no mask was present compared to males [$t = =1.06$, $p = .03$] (Figure 3D). There was no gender difference when masks were present [$t = -.68$, $p = .17$].

Compound emotion recognition

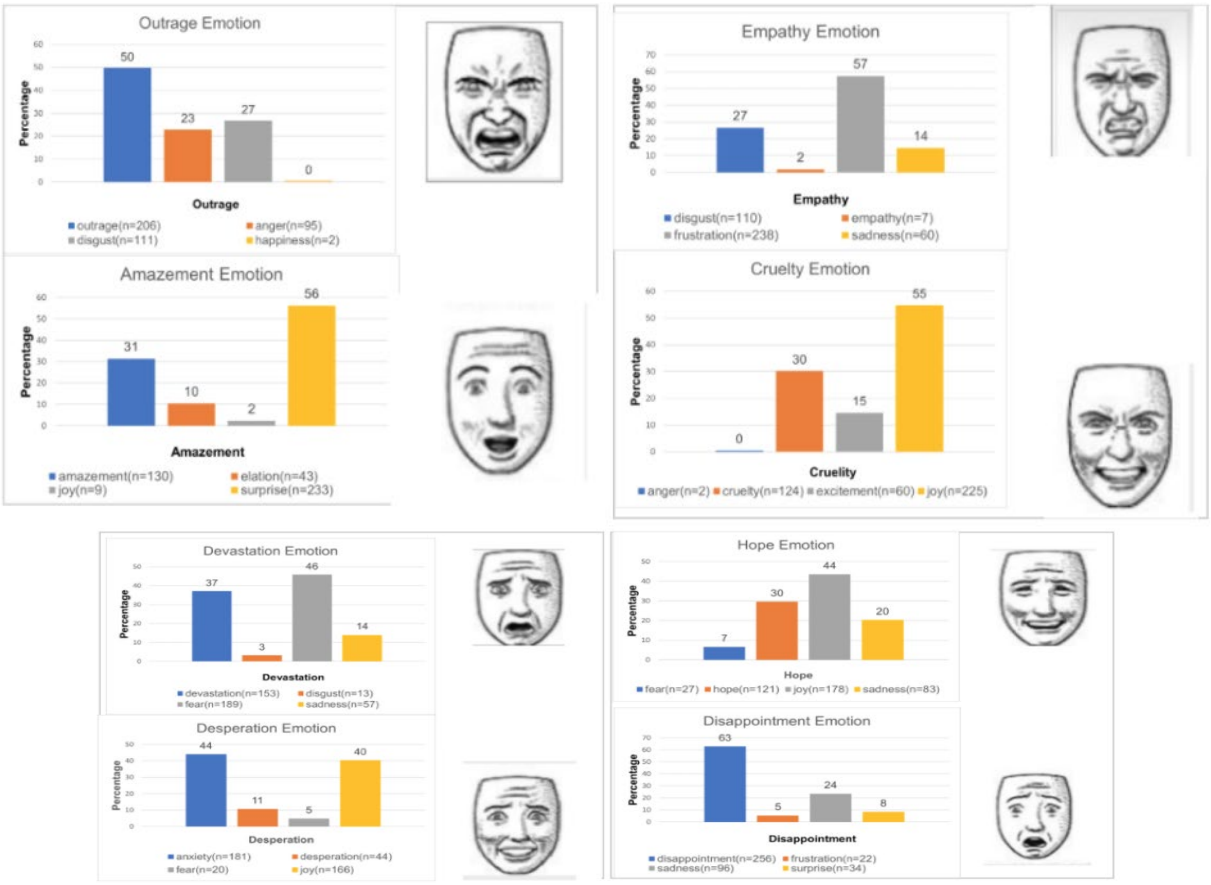

Figure 4. The compound emotions surveyed were Outrage, Empathy, Amazement, Cruelty, Devastation, Hope, Desperation, and Disappointment with graphs showing percent accuracy in recognizing the compound emotional expressions.

Next, the accuracy of identifying compound emotional expressions was examined (Figure 4). Age had a significant effect on compound emotion recognition (Figure 5). There was a significant effect of Cruelty across age groups [$F(3,410) = 52.63$, $p < .001$], where children and young adults (age group 0-20) could recognize Cruelty better compared to the participants of the older age groups. This may be due to the anti-bullying attitude taught in school. It was observed that Empathy was the most difficult emotion to recognize with only 2% accuracy overall and no significant age effects ($p = .487$). One possible reason for this could be that Empathy might have looked similar to other emotions such as frustration or Disgust. There was a significant effect of Desperation across age groups [$F = 3.97$, $p = .008$], where Desperation was more accurately recognized in the age groups under 40, compared to the age groups over 40. It was also observed that participants in the age group 0-20 and 40-60 were both able to more accurately identify the compound emotion Outrage compared to the other age groups surveyed [$F = 2.91$, $p = .034$]. Older adults (60+) and children under 20 were able to recognize Devastation [$F = 12.87$, $p < .001$] and Amazement [$F = 2.78$, $p = .04$] at a higher accuracy compared to the 20-60 age perhaps due to life experiences and context. The ability to correctly identify Hope varied only slightly across all the age groups and was not significantly different ($p = .70$). It was also observed that participants in the age group 0-20 and 40-60 were both able to more accurately identify the compound emotion Disappointment compared to the other age groups surveyed [$F = 3.06$, $p = .028$].

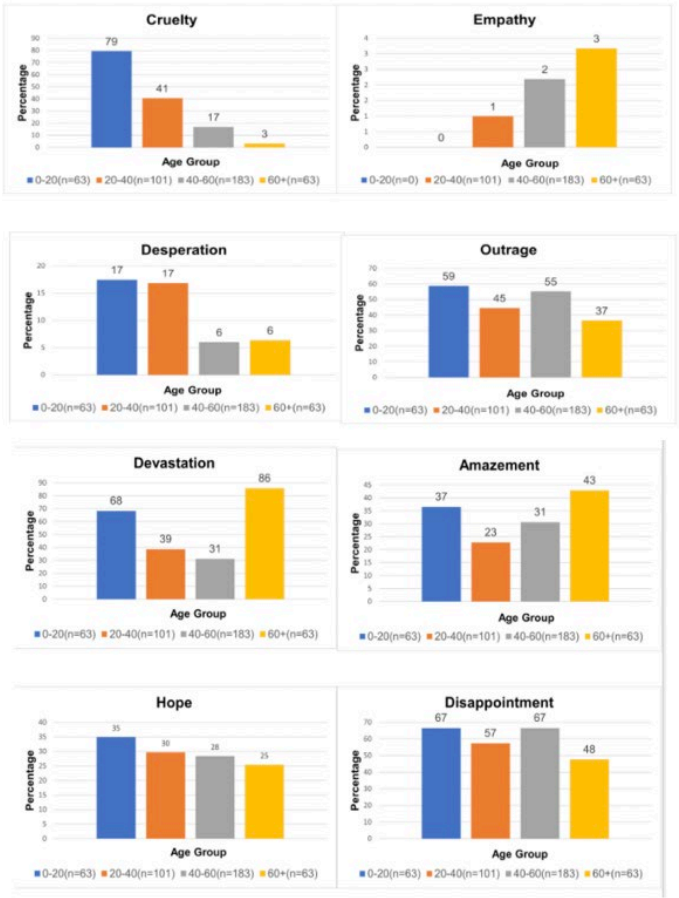

Figure 5. Effect of age on recognizing compound emotions.

When examining the impact of education on recognition of compound emotions (Figure 6), survey participants with elementary through high school level education were able to recognize Cruelty at a higher accuracy compared to respondents with graduate and higher education [$F = 29.20$, $p < .001$]. One possible reason for this observation could be that with continuous training being given at schools, younger kids are more informed and educated about

Cruelty. Empathy was the hardest emotion to recognize with 2% accuracy and no significant effects of education ($p = .817$). Elementary school kids were the most accurate in identifying Desperation [$F = 4.98$, $p < .001$]. Outrage was similarly recognized across all education levels ($p = .404$), although the elementary level participants were slightly more accurate. High school and elementary students were the most accurate in recognizing Devastation [$F = 9.6$, $p < .001$]. This may be because of their susceptibility to negative emotions. There was no significant effect of Amazement across education level ($p = .177$), however, elementary school children were more accurate in recognizing Amazement. Since younger children are usually more easily amazed this could be a possible reason for the observed higher accuracy rate among children in correctly identifying Amazement. Similarly, there was no significant effect of Hope across age groups ($p = .139$), however, Hope was more accurately recognized in the elementary and middle school age compared to older people, probably because of those same reasons. There were no significant effects of education of recognizing Disappointment ($p = .839$).

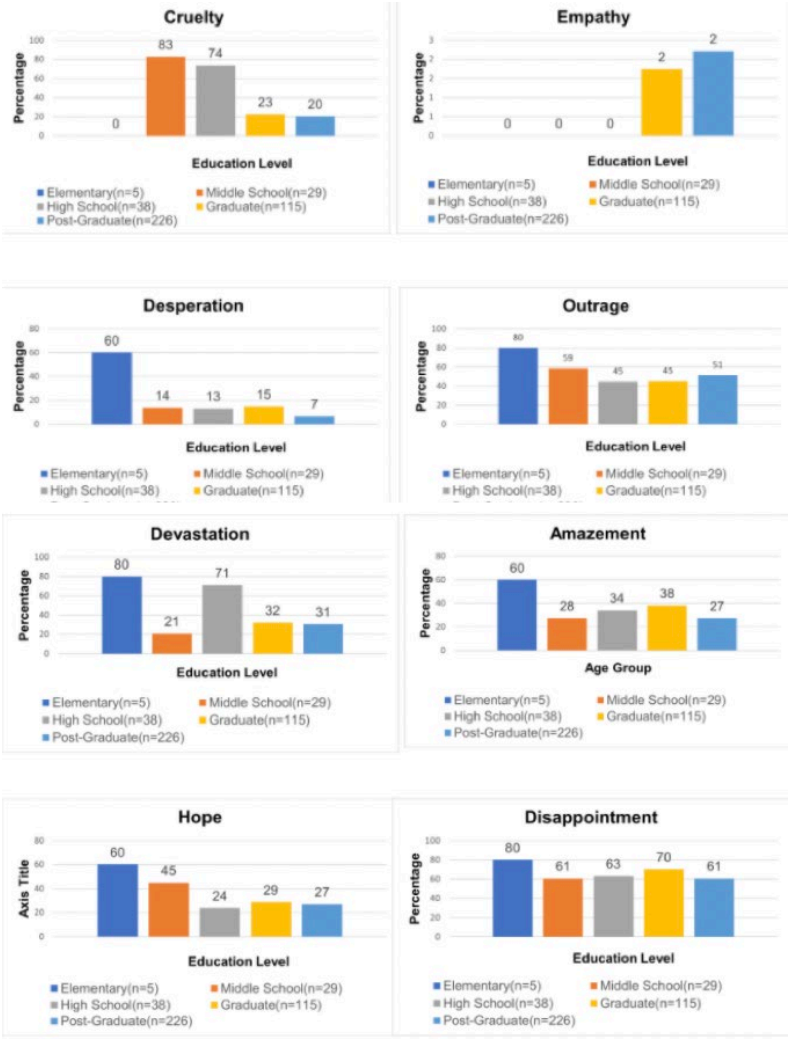

Figure 6. Influence of education on ability to recognize compound emotions.

Comparison of graphs plotting self-reported fitness level with the accuracy of identification of each of the compound emotions showed that there was no constant correlation across all the emotions surveyed (Figure 7). We found two of the compound emotions to be significantly affected by fitness level: Devastation [$F = 2.80$, $p = .04$] and

Disappointment [F = 3.36, p = .019]. The accuracy of correctly identifying Devastation decreased with the increase in fitness level. The moderate and minimal to none exercise levels were the most accurate in recognizing Disappointment.

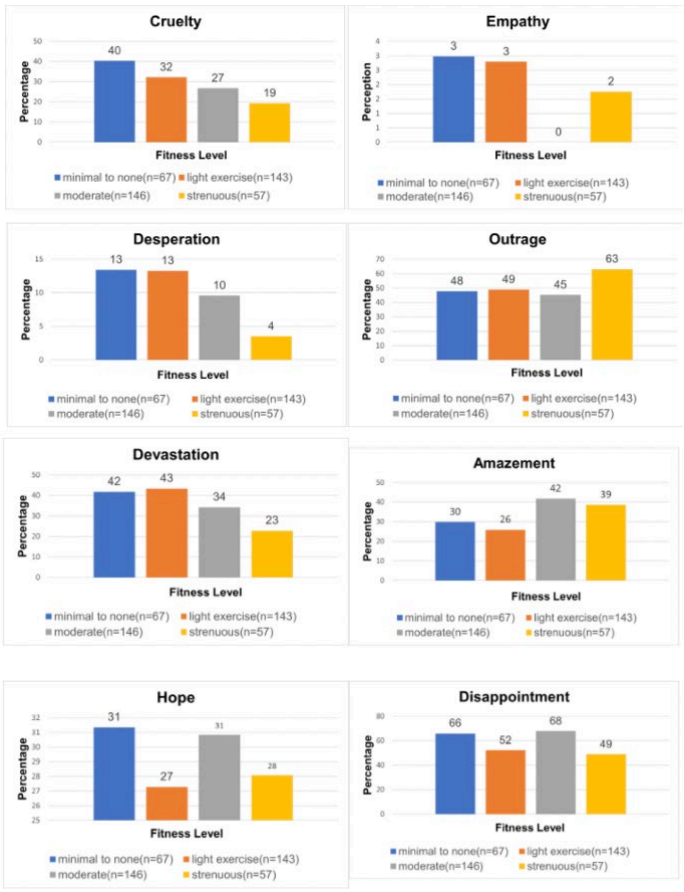

Figure 7. Influence of self- reported fitness on ability to recognize compound emotions.

When examining the impact of gender of recognizing compound emotions (Figure 8), female survey participants were more accurate in recognizing compound emotions of Desperation [F = 3.93, p = .048], Outrage [F = 8.44, p = .004], Hope [F = 5.03, p = .025], and Disappointment [F = 9.73, p = .002]. Men were more accurate in recognizing compound emotions of Cruelty [F = 4.73, p = .030] and Outrage [F = 8.44, p = .004]. Devastation and Amazement were not significantly different across genders.

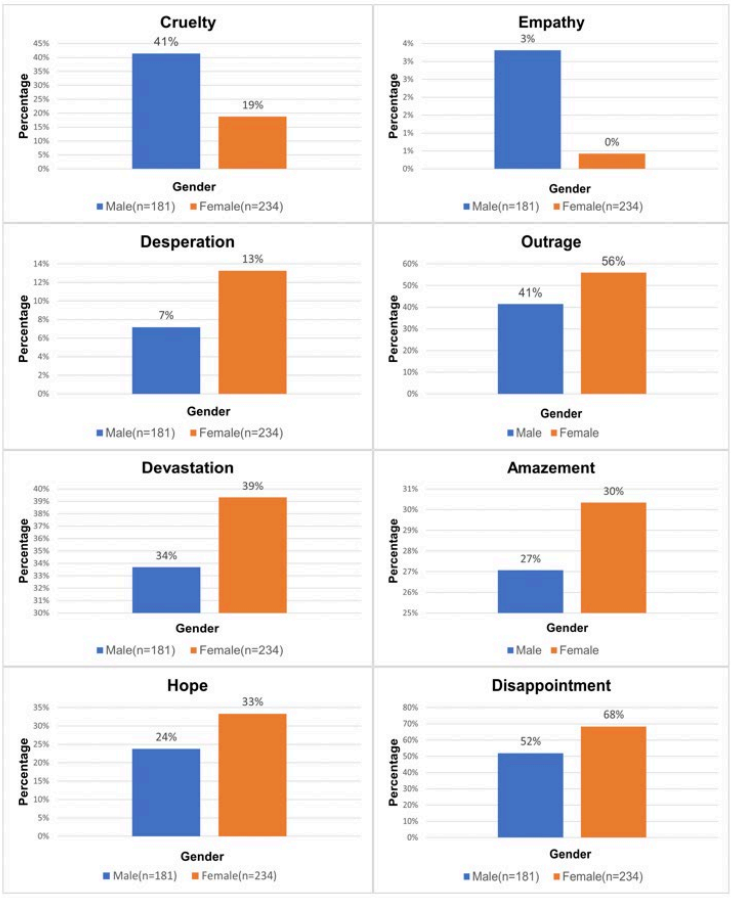

Figure 8. Influence of gender on ability to recognize compound emotions.

4. Conclusions and Discussion

This study demonstrated that basic emotions were universally recognized (91%) through facial expression irrespective of age, gender, education, and fitness level. The 9% of the subjects who did not correctly recognize the basic emotions were overwhelmingly older men in the 60+ age groups. Facial coverings were associated with a decrease in people's ability to recognize basic emotions and only 83% of the respondents could recognize these emotions correctly. Ability to accurately identify basic emotions varied inversely with age, education, and fitness level. Compared to basic emotions, survey participants had difficulty correctly identifying compound emotions across all demographic groups in this study. The accuracy with which the compound emotions were recognized varied widely. While approximately half of the participants could recognize emotions like Disappointment and Outrage, only 2% of the participants could recognize Empathy. The influence of age, education level and fitness in recognizing compound emotions accurately varied for each emotion queried. Compared to males, females recognized most of the compound emotions and all of the basic emotions at a higher accuracy rate across all age groups.

Further research using advanced imaging studies such as fMRI can be pursued in the future to find real time changes in the brain during emotion perception. Linking neuronal activity in the brain by fMRI to a person's ability to recognize various emotions can help understand the scientific reason for emotional differences. Additional behavioral and contextual clues in the faces could unlock a full set of facial expressions making perception simpler as such in the future work we hope to conduct in order to understand the influence of secondary clues on people's ability to unlock facial expressions. Although computational facial recognition has become increasingly powerful and popular, it still

lacks the ability to recognize emotions. We can, therefore, use the knowledge gained in these studies to develop better algorithms that can accurately perceive human emotions.

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