# Emotion Recognition in Asian Faces: How Much of a Difference Do Masks Make?

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**Abstract**

COVID-19 has introduced face masks into everyday life. The social implications of such a phenomenon are important to understand as they affect our day-to-day interactions. Difficulties in emotion recognition, in particular, have been linked to the usage of face masks, but related studies are few in number, present conflicting results, and focus almost exclusively on Caucasian faces. This study assesses the effect of face masks on emotion recognition of Asian faces by high school students. Students ($N$ = 115) at a Long Island High School were recruited to take a survey on SurveyMonkey. Participants were asked to identify the emotion (out of 8) displayed by a given target face and indicate their confidence in their assessment using a bipolar scale rating from 1 = "very unconfident" to 7 = "very confident". A total of 64 Chinese target faces including eight emotions, two males, two females, and two conditions (unmasked vs masked) were presented to participants in a randomized order. Emotions included anger, content, disgust, fear, happiness, sadness, and surprise. This study found that face masks were associated with a significant reduction in accuracy and confidence in assessment of emotion recognition. Recognition of all emotions except neutral was significantly impaired by masks. Recognition of fear in particular was impaired when masked, which was not found in Caucasian faces in previous studies. Emotion misinterpretations also presented some concerning patterns of confusion including the tendency to confuse disgust for anger and fear for surprise. disgust, neutral, content, and happiness had the greatest reductions in confidence as a result of masks. Confusions in the emotion recognition of negative emotions are particularly concerning because the implications of misinterpreting negative emotions are greater than those of positive ones. The results of this study suggest that face masks hinder the ability to accurately assess emotions, posing a threat to everyday interactions and communication. Impairments in recognition as a result of masking were not associated with participant ethnicity. Findings of this study suggest that the use of face masks compromises emotional connections involving Asian target faces to a similar or even greater extent than Caucasian faces. Some limitations included the use of only four individual target faces, a lack of participant diversity, and difficulty in photoshopping face masks onto faces uniformly. Future research can further explore the relationships between acculturation and race/ethnicity of participant, incorporate multiple ethnicities and ages of target faces, and incorporate participants with greater diversity in terms of both age and ethnicity.

## Literature Review

Since the outbreak of COVID-19 as a pandemic, wearing a mask has become an integral part of everyday life. While the public health benefits of mask-wearing pertaining to the transmission of COVID-19 has been extensively studied (Chu et al., 2020), the social implications of wearing masks have received less attention.

In the medical setting, the use of face masks has raised concerns about doctor-patient communication. A study conducted by Kratzke et al. (2021) found that patients had lowered positive perceptions of doctors wearing a face mask. On average, patients in the study believed a surgeon wearing a face mask was less empathetic and trustworthy compared to a surgeon wearing a clear face shield. They were also less comfortable with

the idea of having the surgeon they met wearing a face mask operate on them.

Emotion recognition is an important part of human interactions. Faces are the primary method of recognizing emotions and informing reciprocal expressions (Bruce & Young, 1986; Dimberg et al., 2000). In the education setting, face masks can negatively affect the relationship between teachers and students, a relationship built on emotional connections. Difficulties in emotion recognition can interfere with outward emotional responses to a peer's face, making it difficult to adjust one's behavior to match behavioral norms. Masks also impair verbal and non-verbal communication, opening the door to miscommunication (Spitzer, 2020).

*Face Masks and Emotion Recognition*

Recent studies have already suggested that face masks confuse emotion recognition. A study conducted by Carbon (2020) shows a significant decrease in accuracy of the emotions of anger, disgust, happiness, and sadness. Accuracy dropped by 14.2, 50.2, 24.6, and 13.4 percentage points, respectively. Confidence in perceived emotions for the emotions of anger, disgust, happiness, neutral, and sadness under a face mask were also significantly impaired. Each of the 36 participants in this study was presented with 72 pictures and was asked to assess the emotion depicted from a list of six choices (angry, disgusted, fearful, happy, neutral, and sad). They were also asked to indicate their personal confidence for each assessment using a Likert scale from 1 (very unconfident) to 7 (very confident). This study was conducted using Caucasian faces from the MPI FACES database (Ebner et al., 2010). No mention of participant ethnicity was made. Results were mirrored in a similar study that also used Caucasian faces, finding that target faces wearing face masks were associated with a significant decrease in accuracy ($p < .001$) of emotion recognition (in the same six emotions) compared to unmasked faces. Participants of this study lived in Germany and 90% indicated that German was their sole ethnicity (Grundmann et al., 2021).

It is generally agreed that the eye and mouth region are the most important regions of the face for emotion recognition (Blais et al., 2012; Spitzer, 2020). Previous emotion recognition studies have utilized tiled target images to determine which regions of the face are most informative. Tiled portions of a face image would randomly reveal themselves and respondents were instructed to stop the sequence once they recognized the emotion. Respondents that successfully identified emotions generally relied on tiles containing the eye and mouth region (Spitzer, 2020; Wegryzn et al., 2017). Therefore, when the mouth, one of these informative regions of the face, is obscured with a face mask, there is a large potential for impaired emotion recognition.

There is general agreement on how specific regions of the face may most accurately predict certain emotions, with a few contentions. Overall, detection of the emotions anger, fear, and sadness relies heavily on the eye region (Bombari et al., 2013; Schurgin et al., 2014; Wegrzyn et al., 2017). While assessment of the emotions disgust and happiness (described as "joy" in Schurgin et al., 2014) showed prolonged fixation in the mouth region for studies conducted by Wegrzyn et al. (2017) and Schurgin et al. (2014), Bombari et al. (2013) presented a slight contention, finding that the mouth region (in addition to the eye region) was also important for recognition of fear.

Existing studies pertaining to the effect of face masks on emotion recognition during the pandemic have generally limited their target faces to Caucasian faces (Carbon, 2020; Grundmann et al., 2021). Participants surveyed have also been of the same race/ethnicity as target faces (Caucasian). Thus, results of existing studies may not be applicable to faces of race/ethnicities other than Caucasian due to cultural differences in emotion recognition and expression (Jack et al., 2009; Beaupré & Hess, 2005).

In several studies, the ethnicity of participants has been found to influence emotion recognition. Jack et al. (2009) found that East Asian observers assessed emotions with bias towards the eye region while Western Caucasian observers distributed

their attention more evenly across the face. A similar study conducted among Sub-Saharan African, Chinese, and French Canadian individuals found that French Canadians were more accurate in decoding shame and sadness. The expression of emotion may also be influenced by the ethnicity of the target face. Fear, when expressed by Sub-Saharan Africans, was recognized with the greatest accuracy by all groups, possibly due to expressive morphological features of the face (Beaupré & Hess, 2005).

There are various arguments as to why individuals may have generally greater accuracy when decoding emotions expressed by their own ethnic group. One argument points to subtle differences in expression across different cultural groups, making it more difficult for out-group members to recognize emotions (Elfenbein & Ambady, 2002). Another suggests that general differences in cultural decoding (Matsumoto, 2002), attributed to culturally learned display rules and cultural norms (Ekman & Friesen, 1969), may be the culprit for variations in cross-cultural interpretations of emotions. However, previous studies have mixed results regarding the role of race/ethnic concordance in emotion recognition (Matsumoto, 1992; Prado et al., 2014). In Prado et al. (2014), although Australian Caucasian participants recognized Caucasian expressions significantly better than participants from Mainland China, Mainland Chinese respondents did not recognize Chinese expressions more accurately than Australian Caucasians. In Matsumoto (1992), ethnic concordance between American and Japanese participants/judges and poser faces was not found to significantly influence accuracy of emotion recognition.

Previous studies have generally found Asian observers to less accurately decode the negative emotions of anger, sadness, and fear compared to Caucasian counterparts (Biehl et al., 1997; Matsumoto, 1992). Explanations for this phenomenon support the existence of general differences in cultural decoding as a result of cultural norms. Asian culture emphasizes a collectivist nature, encouraging moderation of emotions and a lack of expression of negative emotions, which in turn leads to lower recognition of negative emotions compared to more individualistic western cultures (Beaupré & Hess, 2005; Prado et al., 2014). Collective cultures may be less tolerant of negative emotions than individualistic cultures, encouraging displays of emotion that limit group disharmony (Matsumoto, 1990). Contributing to this point, a study conducted by Prado et al. (2014) found that the emotions of fear, anger, and disgust in Chinese faces were least accurately assessed across Australian Caucasians, people of Chinese heritage living in Australia, and mainland Chinese respondents within the emotions tested (happiness, sadness, fear, anger, surprise and disgust). Exploring Asian faces in the context of masking can help contribute to a greater understanding of the cross-cultural effects of face masks on emotion recognition.

Many studies exploring emotion recognition have included participants with a wide range of ages but have often omitted the high school age of participants, generally including participants of elementary school age and adults (Carbon, 2020; Roberson et al., 2012). Younger participants tended to focus on the eye region of the face while adults, better versed in configural processing (the ability to analyze multiple facial features at the same time), put more emphasis on the mouth (Roberson et al., 2012; Schwarzer, 2000). Although the general accuracy of perceived emotions of younger participants was below that of adults (3–4-year-olds having about 60% accuracy, 5–6-year-olds with 70%, and 7–8-year-olds with around 85% compared to adults having >95% accuracy), the emotion recognition of participants under the age of nine was not impaired by face masks. This was unlike older children (9–10-year-olds) and adults who dropped from 90–100% correct to 60–70% correct emotion assessment (Roberson et al., 2012) when a face was masked. This result is likely due to adults being well versed in configural processing. Adults are used to analyzing multiple features of the face as a whole, so obscuring certain regions has led to larger decreases in accuracy compared to children who focus on one region of the face. Configural

processing is predicted to reach maturity around 15 years of age (Mondloch et al., 2002), which, combined with the use of face masks, has the potential to confuse emotion recognition in teenagers to a greater degree than younger children.

Another demographic factor in emotion recognition is gender. Females have historically performed better than males in emotion recognition tasks (Joseph & Newman, 2010). In a recent study, adult males compared to females experienced a significantly greater decline (odds ratio = 0.79) in accuracy of emotion recognition (Grundmann et al., 2021), indicating that emotion recognition was less impacted by face masks for female respondents.

The aim of this study was to determine the effect of face masks on emotion recognition of Asian faces by high school students. Studies similar in nature to this study have utilized only Caucasian faces and have also excluded participants in high school. This study seeks to broaden the understanding of the effects of face masks on emotion recognition of different racial/ethnic groups and age groups. I hypothesized that: *Hypothesis 1:* Accuracy and confidence of emotion recognition in masked faces would be lower than those without a mask. *Hypothesis 2:* Since high school students are at the age when configural processing matures, I hypothesized a significant difference between unmasked and masked conditions, more similar to confusion trends in adults (Roberson et al., 2012). *Hypothesis 3:* Because shared cultural heritage may aid Asian participants in assessing emotions of Asian faces, mask-induced impairment in emotion recognition would be lower for Asian participants than for non-Asian participants. *Hypothesis 4:* Recognition of disgust, happiness, and fear would be impaired to a greater degree because of their reliance on the mouth region for expression. *Hypothesis 5.* Female participants would perform better than males in emotion recognition under both unmasked and masked conditions.

## Method

### *Participants*

High school students were recruited from AP Psychology and Science Research classes at Great Neck South High School. Extra credit was offered as an incentive for participation in the study.

### *Materials*

Participants were asked to complete an online survey. In the survey, participants were presented with a picture of a person's face, then asked to identify the emotion expressed (from a set of eight options) as well as to indicate how confident they were in their assessment. Confidence in assessment was presented as a 7-point bipolar scale with values of very unconfident, unconfident, slightly unconfident, neutral, slightly confident, confident, and very confident. Permission was obtained from Dr. Pei Sun to use target faces from the Tsinghua Facial Expression Database (FED) in the survey. Demographic questions regarding participant race/ethnicity, gender, and age were also asked at the conclusion of the survey.

The target faces in the Tsinghua FED have an overall 79.1% correct emotion identification rate, validated by 34 young (ages 19–35) and 31 older (aged 58–72) native Chinese face raters (Yang et al., 2020). Although other facial expression databases including Asian faces exist, the Tsinghua FED has the greatest number of target faces (a total of 110 individuals) and includes both older and younger faces. The pilot study compared emotion recognition of older versus younger faces. However, there was no significant difference in accuracy found. This study utilized the same group of target faces, this time only using younger faces, out of convenience. Additionally, the FED includes specifically Chinese faces while other databases include Japanese or other Asian groups. Chinese faces in particular were of interest for this study because a previous study found that negative emotions (such as anger, disgust, fear) were recognized less often

than positive emotions: making a case for exploring emotion recognition of specifically Chinese faces (Prado et al., 2014).

This study used pictures of four unique Asian faces: two young males and two young females (ages 19–35). For each individual face, eight emotions were shown, including anger, disgust, fear, sadness, surprise, neutral, content, and happiness. To develop a masked version of the target faces, a stock image of a blue surgical mask was photoshopped onto faces using the editing software GIMP. Face masks were individually placed on images and adjusted to fully cover the mouth and nose, the region obscured by a face mask. Refer to Appendix for examples of target face images.

In total, 64 face stimuli were used in this study. Each of the four individual faces (two females, two males) were shown expressing all eight emotions and were then shown again in the masked condition (4 individuals x 8 emotions x 2 conditions = 64). Questions were randomized and presented in a survey hosted by SurveyMonkey. All responses were anonymous.

*Procedure*

Participants were invited to a Google Classroom where they were given access to a PDF consent form. The consent form details survey instructions, procedures, and provides example questions. Although joining a Google Classroom requires an email address, surveys on SurveyMonkey do not require email addresses to be filled out. Therefore, all responses were anonymous and unable to be connected back to participants. Participants had the option of discontinuing the survey whenever they chose to and were not required to indicate their demographics. After submission of the parental assent form, students were emailed instructions and a link to the survey. The survey took on average 12 minutes to complete, and no time limit was imposed for any response.

*Data Analysis*

Data was exported to Excel using the "export file" button on SurveyMonkey and analyzed using linear regressions in STATA. Sample means and 95% confidence intervals were derived for accuracy in emotional recognition by the study condition (unmasked vs. masked), both overall and for each of the eight expressed emotions of the target faces. Distribution of reported confidence was examined by the study condition. To gain deeper insight into emotion misinterpretations, two confusion matrices for the unmasked and masked conditions were generated.

Analysis was conducted to further examine whether masks impaired emotional recognition differently by respondent gender, gender of the target face, and gender concordance between the respondent and the target face. Impairment in emotion recognition was compared between Asian and non-Asian respondents. Respondents who reported their race/ethnicity as "mixed" and had Asian heritage were counted as "Asian" in this analysis. Respondents who chose not to indicate their ethnicity or gender were included in analysis of accuracy for unmasked vs. masked conditions but excluded from comparisons of accuracy by demographic group.

Each respondent contributed 64 observations to the analysis. Because answers contributed by the same respondent were not independent, robust standard errors and 95% confidence intervals were derived by taking into account clustering at the respondent level by using the cluster() option in STATA 16.0 commands.

## Results

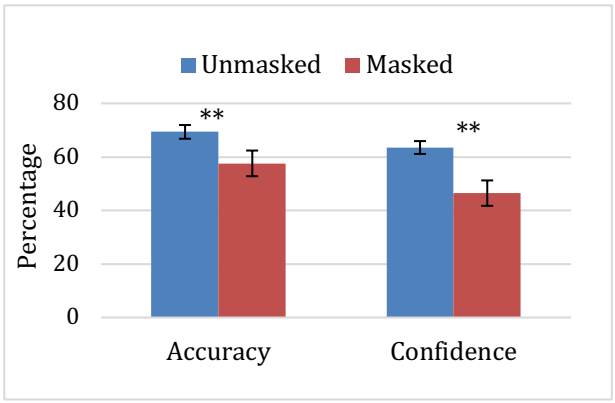
*Participant Demographics*

This study collected a total of 115 responses. Participants had ages ranging from 15–18 with an average age of 16.3. Roughly 68.70% of participants were Asian or Asian American, 18.26% White, 2.61% Hispanic or Latino, 0.87% Black or African American, 4.35% Mixed Race, and 5.22% preferred not to indicate their ethnicity. There were 67 females, 44 males, and four

participants preferred not to respond to the gender question.

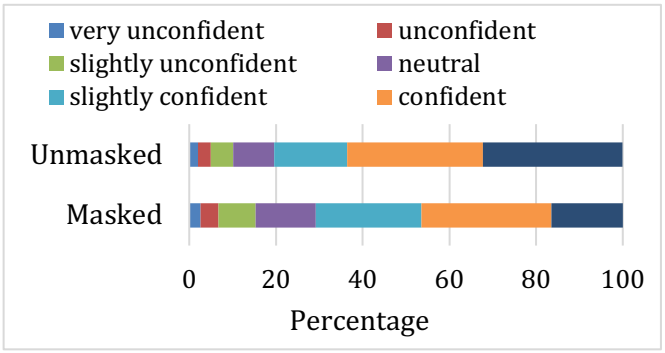
*Mask-Induced Impairment in Recognition and Confidence*

Overall, face masks were observed to significantly impair the accuracy of emotion recognition by 11.77 percentage points (from approximately 69.35% to 57.58%, $p < .001$; Figure 1). Overall confidence in assessment was also impaired by face masks. In the unmasked condition, 63.51% of participants were either confident or very confident in their assessment of a given emotion. Only 46.47% of participants were confident or very confident in their assessment of emotions in the masked condition (a 17.04 percentage-point decrease). The distribution of confidence in unmasked vs masked conditions is also of interest (Figure 2). In the masked condition, the frequency of respondents feeling "very confident" in their assessment of emotions dropped from 32.28% to 16.47% (a 15.81 percentage-point reduction) compared to the unmasked condition. Those reporting "confident" did not change much (30.00% vs. 31.22%) while the lower confidence ratings (neutral, slightly unconfident, unconfident, and very unconfident) all increased.




*Note*. Confidence level percentages represent the proportion of confidence ratings indicating "confident" and "very confident" in emotion recognition assessment. Error bars represent 95% confidence interval. $N = 115$ participants x 64 questions. ***$p < .001$.

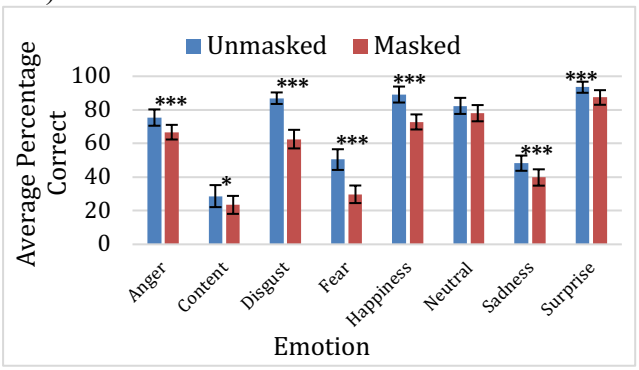
**Figure 1. Accuracy of Emotion Recognition and Confidence Level Across Unmasked and Masked Conditions**




*Note*. $N = 115$ respondents x 64 questions/respondent.

**Figure 2. Distribution of Confidence Ratings Unmasked vs Masked**

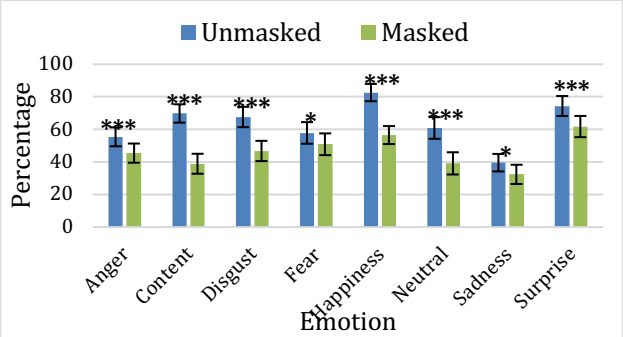
The degree of face-mask-induced impairment on recognition differed by emotion. All eight emotions (with the exception of Neutral) saw a significant decrease in the accuracy of emotion recognition. Neutral still had a borderline significant impairment of accuracy ($p = 0.059$). The magnitude of impairment differed across emotions (Figure 3). Compared to the unmasked condition, accuracy of emotion recognition in the masked condition for disgust went from 86.96% to 62.61% (24.35 percentage points, $p < .001$). Fear decreased from 50.43% to 29.78% (20.65 percentage points, $p < .001$). That of happiness from 89.13% to 72.83% (16.3 percentage points, $p < .001$). Anger decreased from 75.43% to 66.74% (an 8.69 percentage point difference, $p < .001$). Sadness from 48.26% to 39.78% (8.48 percentage points, $p = 0.001$). Surprise from 93.48% to 87.39% (6.09 percentage points, $p = .001$). Content dropped from 28.70% to 23.48% (a 5.22 percentage point difference, $p < .05$). Neutral from 82.39% to 78.04% (4.35 percentage points, $p = .059$).




*Note*. Error bars represent 95% confidence interval. $N = 115$ respondents x 64 questions/respondent (four unique target faces individually expressed all eight emotions).*$p < .05$. ***$p < .001$.

**Figure 3.** ***Accuracy of Emotion Recognition Across 8 Emotions, Unmasked vs. Masked***

Confidence in assessment decreased in all eight emotions when comparing masked to unmasked conditions (Figure 4). The greatest percentage point decreases of confidence were found in the emotions of Disgust (20.87 percentage points, $p < .001$), Neutral (21.74 percentage points, $p < .001$), Content (30.87 percentage points, $p < .001$), and Happiness (26.09 percentage points, $p < .001$).




*Note*. Confidence level percentages represent the proportion of confidence ratings indicating "confident" and "very confident" in emotion recognition assessment. Error bars represent 95% confidence interval. $N = 115$ participants x 64 questions. $*p < .05$. $***p < .001$.

**Figure 4.** ***Confidence in Assessment Across Eight Emotions, Unmasked vs Masked***

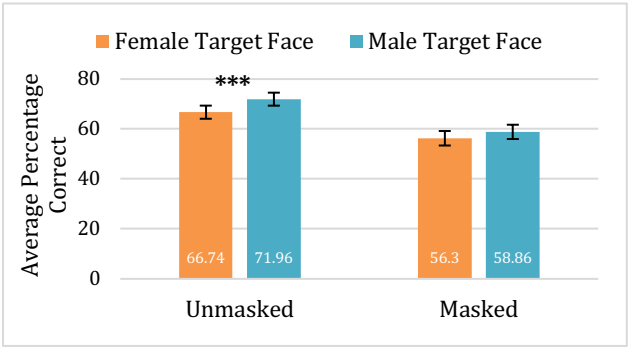
### *Confusion in Assessment of Emotions*

In the confusion matrix presented (Table 1), the dark green diagonal stretching from the upper left to bottom right hand corner indicates a greater level of agreement between emotions expressed by target faces and those perceived by respondents. The darker the green, the greater the agreement. The diagonal is noticeably more uniform and darker in the unmasked condition compared to the masked condition. In the masked condition, emotions slightly confused with each other in the unmasked condition were generally similarly confused, just to a greater degree. In the unmasked condition, the emotions of Content, Fear, and Sadness had low accuracy, the expressed and perceived emotions agreeing less than 60% of the time. Content was accurately recognized 28.7% of the time, confused to the greatest degree with happiness (63.91%). Fear was correctly recognized 50.43% of the time, being confused with Disgust (24.35%) followed by Surprise (18.04%). Sadness was correctly recognized 48.26% of the time, commonly confused with Disgust (22.61%), followed by Anger (11.09%). Some other observations include Anger's tendency to be confused with Disgust 10.43% of the time, Happiness' slight confusion with Content (7.39%), and Neutral's with Content (6.09%).

Accuracy in recognition for all eight emotions declined in the masked condition (Figure 3). Several emotions were confused for each other more than others (Appendix A). For anger, confusion with disgust became less prominent and confusion spread out more evenly amongst the other emotions. In particular, anger's confusion for neutral increased from 4.78% to 10%. Content's tendency to be confused with Happiness (63.91% in the unmasked condition) decreased by 28.04 percentage points in the masked condition. Misinterpretations of content when masked spread more evenly between happiness and neutral (35.87% and 31.52%, respectively). Disgust, which showed no leanings towards confusion with other emotions when unmasked, was confused with anger 25.22% of the time when masked. The emotion of fear, which showed previous tendencies to be confused with disgust and surprise, leaned heavily towards surprise (rising from 18.04% to 53.48%) in the masked condition. The tendency for happiness to be confused for content was worsened under a mask (7.39% confusion unmasked vs 15.65% masked) with content. Neutral's leaning towards confusion with content (6.09% confusion when unmasked) was increased slightly in the masked condition (7.61%). Neutral's confusion with sadness was also worsened with the addition of a face mask (5.65% unmasked vs. 10.0% masked). Sadness's tendency to be confused with anger and disgust when unmasked decreased slightly in the masked condition and confusion with neutral increased from 8.91% to 16.52%. Surprise continued to show minimal confusion with other emotions. Overall, face masks increased the ambiguity of each emotion.

*Associations Between Mask-Induced Impairment and Demographic Variables*

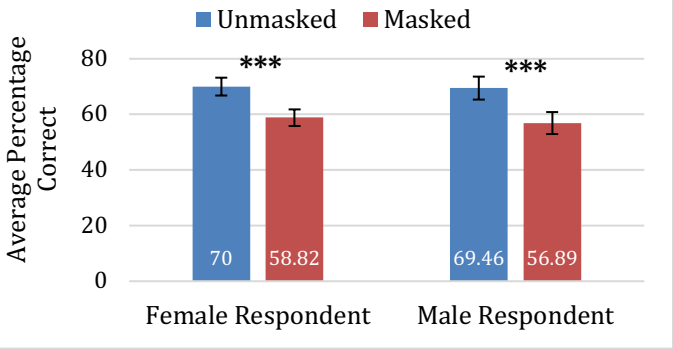
Masks significantly impaired emotion recognition for target faces of both genders ($p < .001$) but lessened the difference between emotion recognition of the two target face genders (Figure 5). In the unmasked condition, male target faces were associated with higher accuracy in emotion recognition when compared to female target faces in both unmasked (5.22-percentage-point higher, $p < .001$) and masked (2.56-percentage-point higher, not significant difference) conditions.




*Note*. Error bars represent 95% confidence interval. $N = 115$ respondents x 64 questions/participant. ***$p < .001$.

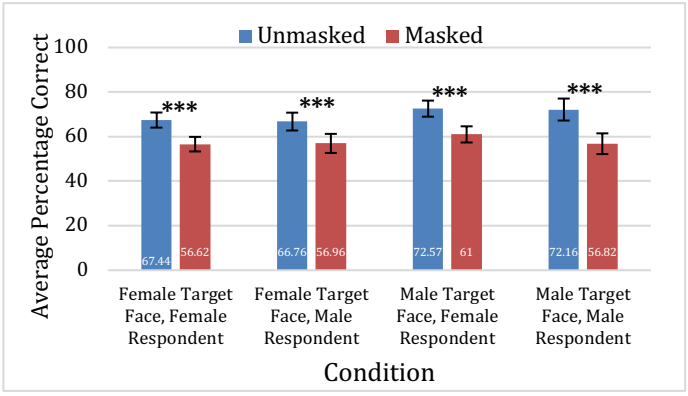
**Figure 5.** ***Accuracy of Emotion Recognition by Target Face Gender***

In both respondent genders, the masked condition significantly impaired accuracy of emotion recognition ($p < .001$) (Figure 6). Impairment of recognition did not differ by respondent gender. Males had a 1.38 percentage point greater impairment than females, but this difference was not statistically significant ($p = .426$). Respondent and target face gender concordance was not associated with mask-induced impairment (Figure 7).




*Note*. Error bars represent 95% confidence interval. $N = 111$ participants x 64 questions/participant (four participants preferred not to indicate their gender). ***$p < .001$.

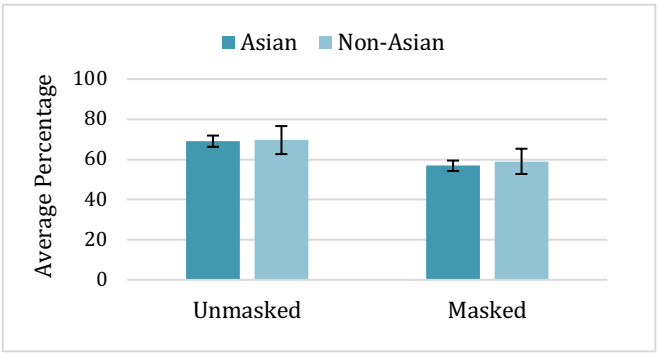
**Figure 6.** ***Accuracy of Emotion Recognition Across Respondent Gender***




*Note*. Error bars represent 95% confidence interval. $N = 111$ participants times 64 questions (four participants preferred not to indicate their gender). ***$p < .001$.

**Figure 7.** ***Accuracy of Emotion Recognition by Target Face and Respondent Gender Concordance***

Race/ethnicity of respondents was not associated with mask-induced impairment in emotion recognition (Figure 8). The mean accuracy for Asian respondents was 1.67-percentage-points lower than that of non-Asian respondents but this difference was not significant ($p = 0.323$).




*Note*. Average percent accuracy of emotion recognition by Asian vs. Non-Asian participant. Error bars represent 95% CI. $N = 109$ respondents x 64 questions/respondent. Results graphed are not significant.

**Figure 8.** ***Average Accuracy of Emotion Recognition Asian vs. Non-Asian Participants***

## Discussion

This experiment sought to explore face masks' effects on emotion recognition in Asian faces by high school students. Previous studies of such effects have predominantly focused on Caucasian faces (Carbon, 2020; Grundmann et al., 2021). Asian faces, often described as less expressive with their emotions (Yamamoto & Li, 2012), are worth studying in the context of face masks given their baseline ambiguity and

heightened risks of misinterpretation when masked. Exploring the effect of face masks on emotion recognition in Asian faces can also increase the overall understanding of emotion recognition across different race/ethnicities. Respondents of the high school age have not been represented in previous studies (Roberson et al., 2012) and are worth studying in part because of the immense social changes present at school. As the COVID-19 pandemic continues and schools reopen with mask mandates, understanding how masks may impair social interactions will be important first steps towards strategies to mitigate such impairment.

Overall, face masks were associated with a 16.97% relative reduction in the accuracy of emotion recognition in Asian target faces. Participants correctly identified unmasked target faces 69.35% of the time (Figure 1), 9.73-percentage-points lower than the Tsinghua FED's accuracy in validation tests. This slight change in accuracy may be attributed to the FED being validated by adult respondents (Yang et al., 2020). Since configural processing matures at age 15 (Mondloch et al., 2002), it is probably not surprising that adults assessed emotions with greater accuracy than high schoolers. It is also possible that the validators of the FED (Chinese people who live in China) had a greater cultural advantage in identifying emotions compared to high school students in the United States, leading to higher accuracy of emotion recognition in the validation versus the results of this study.

The substantial and significant decline in expressed confidence by respondents indicates that face masks impaired respondents' sureness in their assessments. Interestingly, the "very confident" rating dropped drastically (15.81-percentage-points) while "confident" stayed fairly consistent, displaying a mere 1.22 percentage point increase in the masked condition (Figure 2). It is possible that respondents switched from "very confident" to "confident" in their assessments and from "confident" to the other lower confidence levels, inadvertently keeping the percentage of "confident" constant. Respondents could have also just been generally confident in their recognition of emotions. Mask-induced emotion recognition impairment was significant for seven out of eight emotions tested. The emotions of anger (11.52% relative decrease in accuracy in the masked condition compared to unmasked), content (18.19% decrease), disgust (28.0% decrease), Fear (40.95% decrease), happiness (18.29% decrease), sadness (17.57% decrease), and surprise (6.51% decrease) all saw significant impairment in recognition (Figure 3). These findings were also consistent with those of Carbon's 2020 study (conducted without the emotions of content and surprise) which found that masks significantly impaired emotion recognition in Caucasian faces for the emotions of anger, disgust, happiness, and sadness ($p < .001$). Also consistent with Carbon (2020), recognition of the neutral emotion in this study was not significantly impaired. Although fear was not significantly impaired by face masks in Caucasian faces (Carbon, 2020), it was for Asian faces in this study.

The relative decreases in accuracy correspond with the regions of the face thought to best predict their recognition. Anger and sadness, thought to be expressed predominantly in the eye region (Bombari et al., 2013; Schurgin et al., 2014; Wegrzyn et al., 2017), had relatively low decreases in accuracy (11.52% and 17.57% decreases respectively) compared to other emotions when masked. Surprise also had a relatively low decrease in accuracy (6.51%) which suggests its reliance on the eye region for expression. On the other hand, disgust and happiness, thought to be expressed predominantly in the mouth region (Bombari et al., 2013; Schurgin et al., 2014; Wegrzyn et al., 2017), had relatively higher decreases in accuracy compared to other emotions when masked (28% and 18.29% decreases respectively). This study found that fear was associated with a startling decrease in accuracy (40.95% relative reduction) in the masked condition. A previous study found that recognition of fear in Caucasian faces relied more heavily on the eye region (Wegryzn et al., 2017), which is left unobscured by a face mask. It is possible that Asians tend to utilize more of the obscured mouth region to express fear compared to Caucasians,

leading to greater impairment. In a previous study, East Asian observers were presented with Japanese faces and Western Caucasian observers with Caucasian faces. The study found a significant deficit in East Asian observers in recognizing fear, but not among Western Caucasians (Jack et al., 2009). Results of this study suggest that Asian faces rely heavily on the mouth region to express fear, thus, leading to significant impairment in assessment in the masked condition.

In this study, certain emotions were confused with others in both the unmasked and masked conditions (Table 1). Negative emotions such as anger, disgust, and sadness were confused with each other, and positive or neutral emotions such as content, neutral, and happiness were confused with each other. Compared to other emotions, neutral, surprise, anger, happiness, and sadness displayed relatively smaller degrees of disagreement between the expressed and perceived emotion.

Sadness had the lowest rate of accuracy unmasked (48.26%) second only to content and was confused with multiple emotions in both the unmasked and masked conditions. Confusion of sadness for other emotions became more disbursed under the masked condition. One noticeable result is that misinterpretation of sadness shifted primarily from disgust when unmasked but to neutral when masked. This change suggests that masks have the effect of dampening the intensity or severity of emotions, a particularly concerning possibility given that emotions are essential to communication and facilitate human interactions (Bruce & Young, 1986).

Of note, under the unmasked condition, content (28.7% accurate) was confused for happiness at an alarming 63.91% of the time. In the masked condition, content was confused with happiness (35.87%) and neutral (31.52%), suggesting the ambiguity of content to study respondents. In the FED, content is described to be a "smile without teeth" or a subtle version of happiness. Participants in this study were not given definitions of emotions shown. Instead, they answered questions based on their personal interpretations. The personal interpretations of emotions may have also caused some emotions to be more accurately assessed than others.

The emotions of disgust and fear had prominent decreases in recognition in the masked condition (24.35 and 20.65 percentage points, respectively). Unmasked, disgust had a 86.96% accuracy rate with a small 5% confusion with anger. This confusion was amplified in the presence of a face mask: assessment of disgust fell to 62.61% accurate and was confused for anger 25.22% of the time. Masked disgust (43.7%) in Carbon (2020) was also heavily confused with anger (37.8% of the time). This confusion is of concern because when masked, a person who is aversive of a situation may be perceived as an irritated or even aggressive person. Fear in the unmasked condition was correctly assessed 50.43% of the time, confused with disgust (24.35%) and surprise (18.04%) most prominently. Masked fear, however, had an accuracy rate as low as 29.78%, and was perceived as surprise 53.48% of the time. This is another particularly concerning finding because of the sheer magnitude of confusion, but also the implications: a person who is afraid of something in a certain situation can be misinterpreted as a person who is feeling shocked at an unexpected circumstance. In addition, this finding seems to apply specifically to Asian faces. The recognition of fear in Caucasian faces showed little confusion with other emotions (92.5% correct assessment when unmasked, 93.5% correct masked) (Carbon, 2020). It is of interest to note that a confusion matrix generated in the validation of the FED displayed similar unmasked confusions in recognition. Disgust was confused with anger 12.09% of the time and fear confused with surprise 18.89% of the time. The slight inherent confusions between database images may play a role in accuracy of emotion recognition in this study.

The gender of target faces had no significant effect on emotion recognition. In a previous study conducted by McDuff et al (2017) comparing the expressiveness of female versus male faces in participants from France, Germany, UK, US, and China, results suggested that female faces were generally more expressive. The same

study found that male facial actions tended to be centered in brow furrows while women used more smiles and inner brow raises. Although brows are a dominant part of the upper region of the face, a region unobscured by face masks, emotion recognition of male target faces in this study only outperformed female target faces by 2.56 percentage points in the masked condition (Figure 5). These results highlight the importance of the mouth region for both genders in emotion expression and recognition.

This study surveyed participants of different racial/ethnic backgrounds. This is in contrast with existing studies of mask-induced impairment in emotion recognition whose participants were the same race/ethnicity as target faces (Carbon, 2020; Grundmann et al., 2021). This study found no difference in mask-induced impairment between Asian and non-Asian participants (Figure 8). The smaller percentage of non-Asian participants in the sample (~30%) may have made it difficult to statistically detect small differences. Participants in this survey attended a high school in the United States and were either born and raised in the United States or highly acculturated, therefore sharing the same race/ethnicity with a target face may have not affected the ability to accurately assess emotions in Asian faces. A previous study comparing emotion recognition of Australian Caucasians (unmasked faces) and people of Chinese heritage living in Australia had comparable findings. Overall, recognition scores between the two groups were similar (82.6 vs. 80.8 % respectively), supporting the idea that acculturation may dull differences in recognition associated with decoding rules pertaining to certain racial/ethnic roots (Prado et al., 2014). It is also possible that non-Asian participants in this study were accustomed to interpreting emotions expressed by Asians as the study population was from a school where Asians are the majority.

Comparing the accuracy of assessment for the eight emotions of the FED (validation) with the unmasked accuracy in this study, the emotions of anger, happiness, and neutral all had differences of less than 10 percentage points (Yang et al., 2020). Jack et al. (2009) suggest that compared to Western Caucasian observers, East Asian observers demonstrate a deficit in recognizing the emotions of fear and disgust. In this study, disgust was recognized 86.76% of the time compared to the 71.06% in the validation, reflecting this trend. However, results of this study may be impacted by the particular target faces used (only four out of the FED's total 110) as unique facial features may facilitate recognition of certain emotions better than others. Recognition of fear was higher in the validation than in this study (62.29% vs 50.43%), and surprise was lower in the validation than in this study (80.29% vs. 93.48%). Content's accuracy in this study is drastically different from its validation (90.71%), coming in at a concerning 28.7%. sadness was validated at 76.41% but was accurately assessed 48.29% of the time in this study. The drastic differences in accuracy for content and sadness are possibly also the result of a difference in age and cultural differences between validators of the FED (adults) and participants in this study (high schoolers).

Although face masks impair emotional recognition and negatively impact social interactions, this is not a reason to disregard their use during a pandemic such as the one we are experiencing. Body language, verbal communication, and social context are all tools that can contribute to recognition of emotional states (Abramson et al., 2021; Golan et al., 2006). Awareness of how masks cause ambiguity in emotions can encourage people to assess emotions more carefully and with greater sensitivity. Findings of this study suggest that such attention and sensitivity should be exercised universally regardless of demographic attributes or concordance between the two sides of a conversation or interaction.

*Limitations and Future Directions*

This study had a few limitations. Participants in this study lacked diversity as they were 60.36% female and 68.7% Asian, all from the same community. The sample population was not completely random—all were either in an AP Psychology class or a Science Research class. This

study also only used Chinese target faces. It is unknown how results may be applicable to other Asian faces, such as Indian, Japanese, or Korean faces.

In addition, to contain the length and burden of the survey, older target faces were not included in this study. Although a pilot study conducted previously did not find significant differences in impairment of recognition by the age of the target faces, this study was thus unable to formally compare emotion recognition and mask-induced impairment by target face age. In the validation, the Tsinghua FED had an overall 79.08% accuracy of emotion recognition, so the database itself may not accurately represent all emotions.

Another measure taken to reduce the length of the survey was the use of only four individual target faces out of the 110 available in the Tsinghua FED. With the limited number of target faces, an individual's unique facial expressions may have had undue influence on emotion recognition by respondents. However, subjecting all respondents to the same set of faces (rather than presenting each with a random set of faces) boosts the internal validity of the study. A lack of uniformity in the photoshopping of face masks onto target faces may also have impacted study results since it is impossible to manually edit images and achieve unvaried results.

Findings of this study raised an important question: are cultural influences more important in interpreting emotions than someone's race/ethnicity? This study found no significant differences in emotion recognition between Asian and non-Asian respondents, suggesting that shared culture may play a greater role than race concordance. To more specifically tackle the question regarding the role of culture (vs. race/ethnicity) on emotion recognition, future studies may consider surveying participants with both racial/ethnic and cultural diversity, such as native Chinese, American-born Chinese, and American-born Caucasians, and comparing their accuracy of emotion recognition. Differences in emotion confusion patterns across different cultures and ethnicities would also be an interesting topic to pursue due to the importance of cross-cultural understanding. A study exploring this could include Asian participants assessing emotions of Caucasian target faces. It would also be of interest to compare impairments in recognition across age groups in the future to further explore the effect age has on emotion recognition.

*Conclusion*

This study assessed the effect of face masks on emotion recognition in Asian faces. It was found that the use of face masks significantly impaired emotion recognition of Asian faces for seven out of eight of the tested emotions (all except neutral) as well as lowered participant's confidence in their assessments. Notable mask-induced impairment was found in the emotions of disgust and fear. The severe impairment in recognizing fear was unique to Asian target faces and not observed in Caucasian faces from previous studies (Carbon, 2020). In the masked condition, disgust was often confused for anger, and fear was often confused for surprise. Demographic factors including target face gender, participant gender, and participant race/ethnicity were not significantly associated with accuracy of emotion recognition. Awareness of impaired ability to recognize emotions when masked can help people to be more conscious during face-to-face interactions and to leverage other modes of communication, potentially minimizing mask-induced impairment to social interactions.

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