

Face Mask Impairment in Basic Emotion Recognition

Xinrui Zhang *

Faculty of Science, The University of Melbourne, Victoria 3010, Australia

* Corresponding Author Email: zhangbei@huaruizk.com

Abstract. Wearing masks is crucial for preventing the spread of viruses. However, their widespread adoption may pose challenges to reading facial expressions. Throughout the COVID-19 pandemic, a flurry of research examined how face coverings affect emotional decoding skills. Yet their findings were inconsistent. This study aims to delve deep into the impact of mask-wearing on emotional recognition. A total of 113 participants (65% female, mean age = 23.61) took part in the study. Participants were tasked with identifying emotions—neutrality, fear, happiness, sadness, anger, disgust, and surprise—by looking at faces both masked and unmasked. Unbiased hit rate (Hu), which helps minimize response biases, was employed as the measure. The results revealed marked differences in Hu scores between the masked and unmasked faces for every emotion, pointing to a detrimental effect of masks on emotion decoding. These outcomes underscore the need for alternative strategies that could effectively blend health safety with the maintenance of vital facial expressions, which is crucial for understanding emotions.

Keywords: Emotion recognition; face masks; facial expression.

1. Introduction

Face coverings are recognized as an effective public health intervention to mitigate virus transmission, particularly during pandemics. In modern society, the utilization of face masks has become prevalent. Masks not only protect individuals from infection but also significantly contribute to public health preservation. Nonetheless, despite the substantial importance of face masks in disease prevention, they also provide difficulties in everyday communication. By covering parts of the face, masks can distort facial expressions, affecting their clarity. Human emotion recognition heavily depends on facial visual features, which serve as key indicators for identifying emotions [1]. Emotions such as happiness and disgust are particularly tied to the lower facial area, especially the mouth, which indicates this area is critical for recognizing these facial expressions [2]. The use of masks obscures essential facial expressions, potentially affecting the precise recognition of emotions. This impacts emotional expression and comprehension in daily life and may also have significant consequences for social interactions and cognitive functioning. This study investigates how face masks influence emotion detection, with a specific focus on how covering the lower face affects the ability to recognize emotions. This is supposed to shed light on how wearing masks influences daily social interactions.

2. Research Subject Introduction

2.1. Concept of Emotion Recognition

Studies have shown that recognizing six basic emotions—fear, happiness, anger, sadness, disgust, and surprise—relies on distinct facial features [1]. The detection of happiness and disgust primarily draws on signals from the lower part of the face [3]. By contrast, recognizing surprise, anger, sadness, fear, and neutralities is predominantly shaped by characteristics in the upper facial region, particularly signals from the eyes [3].

2.2. Review of Previous Studies

Numerous investigations have delved into how face coverings influence emotion recognition. These studies explore not only the direct effects of face coverings but also take into account additional

factors like presentation time and cultural differences. Carbon conducted a study with 41 participants from 19 to 87 years old, aiming to determine how face coverings influence the perception of emotional expressions [4]. Participants were tasked with identifying emotions from a series of facial images and rating their confidence in recognizing specific emotions, including fear, disgust, neutrality, sadness, anger, and happiness. Each participant evaluated emotional expressions from 12 different faces, each of which randomly displayed one of six emotions. The faces presented to participants were either covered by masks or left uncovered. Findings revealed a notable decline in the accuracy of emotional recognition, and lower confidence in assessing the displayed emotions was observed. This suggests that wearing a mask substantially blocks the capacity to understand emotional cues. Another study evaluated how mask-wearing affects emotion recognition when faces are shown for different durations. Tsantani et al. conducted the emotional categorization task with 120 participants whose ages were 18-60 years old [5]. Similar to the study of Carbon, participants rated their confidence in identifying emotions from the presented faces. Participants were split into two groups, each viewing the faces for different durations (500ms and 3000ms). The results demonstrated that face coverings lowered the perceived strength of emotions and reduced recognition accuracy. Moreover, the effect was consistent across different duration presenting groups, which means the presenting duration did not significantly alter the impact of masks on emotion recognition. Consequently, it was broadly acknowledged that face coverings disrupt the ability to interpret emotions.

Grenville and Dwyer conducted research to investigate how face coverings affect emotion decoding [6]. They recruited a cohort of 100 undergraduate students from the UK who were shown images depicting six distinct emotions—fear, disgust, neutrality, sadness, anger, and happiness. The emotions were either covered by masks or without. The stimuli used were photographs of white female models wearing black tops. The results indicated that the effect of face covering differed depending on the emotion being displayed. The ability to recognize disgust, happiness, and sadness was reduced due to mask-wearing. By contrast, neutrality, anger, and fear were not influenced by the existence of masks. However, this study only used white female faces as stimuli, which introduced the bias as the results may not fully represent the emotion recognition abilities of a broader range of gender groups. Parada-Fernández et al. expanded on this by looking at the Spanish population [7]. In their study, 22 Spanish participants classified emotions displayed by both masked and unmasked faces. They evaluated four emotional expressions, anger, sadness, fear, and happiness, using stimuli that included both male and female faces. Results revealed that masks hindered emotion recognition, except in the case of surprise. The non-significant influence of surprise supported this emotion and highly relied heavily on upper facial cues, and face coverings had a slight effect. However, the substantial impact on other emotions emphasizes the crucial role of lower facial features in interpreting emotions. In conclusion, these two studies complement each other by covering some expressions that were not tested. They found a pattern where the recognition of disgust, sadness, and happiness were markedly influenced by mask-wearing.

Miyazaki et al. investigated the impact of face covering on the ability to interpret emotion, specifically using Asian faces and participants from Asian [8]. Participants were tasked with categorizing facial emotions based on various expressions. The emotional stimuli included seven distinct expressions: happiness, sadness, surprise, anger, disgust, neutral, and fear, presented both with and without masks. The findings revealed a significant decline in the accuracy of recognizing fear and happiness when faces were masked, in contrast to unmasked expressions. However, no significant differences emerged for the other emotions—anger, disgust, sadness, neutrality, and surprise. The unexpected lack of a significant impact on recognizing disgust contradicts the assumption that identifying it relies heavily on the visibility of lower facial features. In addition, these findings differ from studies conducted with non-Asian groups, where face coverings did not significantly affect the recognition of disgust and sadness. Miyazaki et al. posited that these variations could be attributed to cultural differences [8]. It was posited that individuals from Asian backgrounds might pay more attention to the eyes, which could bolster their ability to interpret emotions when the

lower face is concealed [8]. Nevertheless, this perspective lacks comprehensive support, as indicated by the findings of Kim et al., who conducted related research focusing on emotion recognition using Asian faces with South Korean participants [9]. The approach used in this study closely followed that of Miyazaki et al., who asked participants to identify the seven basic emotions. The results by Kim et al., however, indicated that emotions such as sadness, anger, surprise, disgust, and happiness were significantly less accurately recognized when the mouth was hidden by a mask, underscoring the critical role the mouth plays in expressing these feelings. This result stands in contrast to that of Miyazaki et al. and implies the impact of covering the lower face may be underestimated. However, it should be noted that while Miyazaki et al. had a substantial sample of 529 participants, Kim et al. only involved 39 participants, raising the possibility that the smaller sample size in Kim et al.'s study may have introduced bias into the results.

Research also demonstrated that varying stimulus presentation durations can yield different outcomes. Bani et al. conducted a study involving 208 medical and nursing students to examine how mask-wearing affects emotion recognition [10]. Participants were randomly divided into two groups: one completed a masked version, and the other an unmasked version. The effects on happiness, sadness, fear, and anger were tested, with photos displayed for 2 seconds without limiting the time for choosing a response. The findings indicated that recognition accuracy declined for happy, sad, and angry faces, though no significant effect was observed for fearful expressions. Rinck et al. used photos with unlimited display time and tested a wider range of emotions [11]. Rinck et al. ran experiments consisting of 168 trials per participant, using male and female actors from the Radboud Faces Database to present emotions such as happiness, sadness, anger, surprise, fear, disgust, and neutrality. Their results showed a notable reduction in recognition accuracy for disgust, fear, surprise, sadness, and happiness, whereas anger and neutral expressions remained largely unaffected. Similarly, Grahlow et al. performed a study with an unlimited presentation time, closely resembling the methodology of Rinck et al. [12]. In their study, a larger sample of 790 participants aged 18 to 89 years were recruited to finish the emotion recognition tasks. The results presented significant reductions in accuracy across all emotions when wearing the mask. This indicated that the presence of a mask had a profound effect on the recognition of all emotions. Thus, differences in presentation duration may be a key factor influencing the degree to which masks impact emotion recognition. In real-life scenarios, presentation time is typically closer to longer durations, which may lead to more misinterpretation or confusion of emotions. Longer presentation times might have a negative impact because participants have more time to speculate on incomplete facial expressions, which could increase the uncertainty in emotion recognition.

A notable limitation in several of the recent studies, such as those by Miyazaki et al. and Kim et al., is their reliance on raw accuracy for analysis. This approach introduces bias, as it neglects to consider the response strategies employed by participants when making judgments [13]. In response to this issue, McCrackin et al. introduced a new metric called the unbiased hit rate (Hu), which measures emotion recognition accuracy while also considering the potential for biased responses [14]. Their findings showed that the presence of masks had a significant impact on the recognition of all emotions, including disgust, anger, sadness, neutrality, surprise, happiness, and fear. The significant impact pointed to the critical role of lower facial features in emotion recognition. It is noticeable that the emotions that highly depend on the features of upper faces also found a significant influence. This finding contradicts previous theories, as emotions thought to rely less on lower facial features were still strongly affected. Moreover, the degree of impact varied across emotions, with disgust being the most affected and happiness the least. The minimal effect on happiness suggests that recognizing this emotion may not depend as heavily on upper facial features as previously assumed.

3. Methods

3.1. Participants

A total of 113 anonymous volunteers participated in the study. Of these, 74 were women, and 39 were men, with ages ranging from 19 to 33 years ($M = 23.61$, $SD = 3.54$). Participants were rewarded with 40¥. All participants provided informed consent through an online consent form.

3.2. Stimuli

The emotional stimuli comprised images depicting seven distinct emotions: neutrality, surprise, fear, sadness, disgust, anger, and happiness. Disgust and happiness were predominantly recognized through cues in the lower facial region, whereas emotions such as fear, sadness, neutrality, surprise, and anger relied more on the upper facial features [3]. Asian faces were used as task stimuli, which were from Han et al. [15]. It was a database of AI-generated emotional facial images. This database was validated with an accuracy higher than 70% [15]. A pool of 70 colored emotional faces was selected, with an equal number of female and male faces. Within images, five from each of the seven discrete emotion categories were prepared for masked and unmasked conditions. Using Adobe Photoshop, surgical masks were digitally applied to the original face stimuli to create the masked versions. The image of the surgical mask was obtained from iStock (<https://www.istockphoto.com/>).

The experiment was administered online. Task display and data collection were through Qualtrics (<https://www.qualtrics.com/>). The images were displayed in color at the center of a white background, with a resolution of 281 pixels in width and 411 pixels in height.

3.3. Procedure

This study aimed to explore the impact of mask-wearing on the ability to recognize emotions. Prior to the emotion identification task, demographic information about age and gender was collected among participants. In the emotion recognition task, participants viewed 70 facial images, each depicting one of seven emotional expressions, presented under either masked or unmasked conditions. The presentation of masked and unmasked faces was randomized. Furthermore, the emotional expressions were also presented in a random sequence.

During each trial, participants were presented with a single face, either masked or unmasked, displaying a specific emotion at the middle of the screen. Beneath the face, buttons representing the seven emotional categories were displayed (Figure 1). The instruction was presented to guide participants clicking the button which corresponding to the current emotional face. Participants had unlimited time to categorize each face, and their responses were recorded.

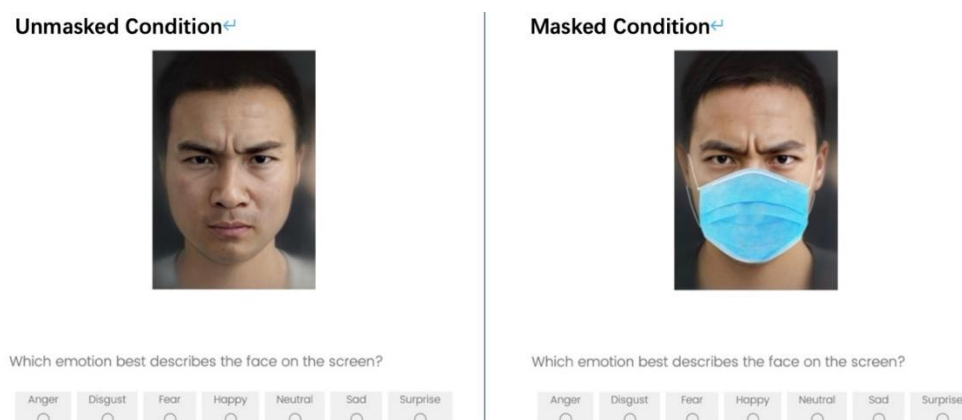


Fig 1. Example trials without or with mask (here: anger) (Photo/Picture credit: Original).

3.4. Data Analysis

The present study measured the performances of emotion recognizing with unbiased hit rate (Hu). Hu could indicate not only the accuracy of emotion recognizing (e.g., correctly selecting anger when

anger is displayed), but also the precision of giving an emotion category response (e.g., choosing anger only when anger is shown without misidentifying other emotions) [14]. This measure reflects controlled emotion recognition performance while accounting for potential response bias.

By considering the seven emotions under wearing masks and without masks context, a total of 14 scores per participant yielded (7 expressions x 2 conditions). To assess how mask usage on emotion recognition performance, there was a repeated-measure ANOVA conducted with two factors: mask condition (mask-wearing and unmasked) and the seven emotions.

3.5. Hypothesis

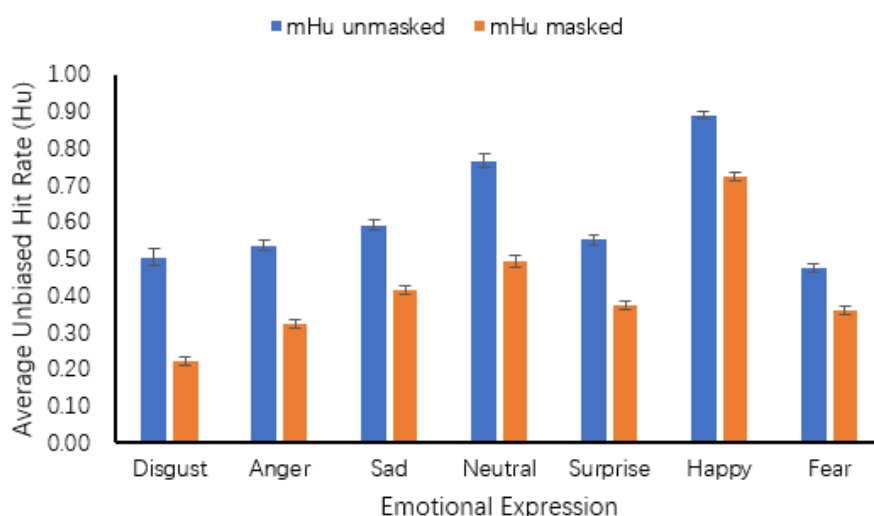
In conclusion, there is general agreement that wearing masks can impair emotion recognition abilities. However, as this area of research is still in its early stages, with a notable increase in studies following the onset of COVID-19, the findings remain inconsistent, highlighting the need for replication studies to validate results. The main goal of this research was to evaluate whether wearing face masks interferes with the ability to recognize emotions and to investigate if this interference is more pronounced for emotions reliant on the lower part of the face. The recent investigation employed Hu as a metric to minimize selection bias.

It was hypothesized that when considering all emotional states collectively, the Hu value of facial expressions concealed behind masks would be substantially lower than the uncovered context. Moreover, it was anticipated that the extent of this discrepancy would fluctuate with each distinct emotion. Specifically, it was hypothesized that emotions such as happiness and disgust—which depend greatly upon the configuration of lower countenance—would exhibit more pronounced variations in their respective Hu scores under masked versus unmasked circumstances. Conversely, for emotions like surprise, sadness, fear, anger, and neutrality, which, given their less reliance on the lower configuration of face, it was expected that the Hu scores between masked and unmasked faces would not show a significant difference.

4. Result

4.1. Descriptive Statistics

The study aimed to evaluate how wearing masks impacted the recognition of emotions. As shown in Figure 2, the overall performance for recognizing emotions in the unmasked condition was above the chance level of 0.50, with a mean Hu of 0.61. In contrast, the performance in the masked condition fell below the chance level, with a mean Hu of 0.41.



Note. Error bars represent standard errors of the mean.

Fig. 2 The figure displays the average unbiased hit rate (Hu) for recognizing the seven emotions under unmasked and masked conditions (Photo/Picture credit: Original).

4.2. The Impact of Face Masking on Distinguishing between Facial Expressions of Various Emotions

A repeated-measures ANOVA was performed with two factors: mask condition (masked and unmasked) and the seven emotions, using Hu values as the measure. The analysis showed significant main effects for mask-wearing, $F(1, 784) = 2396.35$, $p < .001$, $\eta^2 = .75$, and for the type of emotion presented, $F(6, 784) = 537.60$, $p < .001$, $\eta^2 = .80$, indicating that masks significantly impaired emotion recognition.

A significant interaction was also found between face covering and the specific emotion displayed, $F(6, 784) = 55.79$, $p < .001$, $\eta^2 = .30$, implying that the impact of masks on emotion recognition varies depending on the emotion. To delve deeper into the effect of face covering, this study compared the Hu scores for each of the seven emotions between masked and unmasked conditions. Post-hoc t-tests with Bonferroni correction, confirmed significant differences for all seven emotions, with $p < .001$ consistently. The mean differences in Hu scores for recognizing the seven emotions between the unmasked and masked conditions are shown in Figure 3.

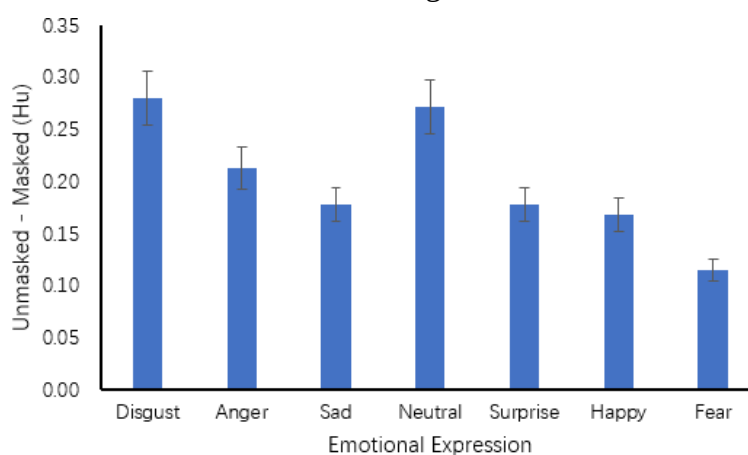


Fig 3. The mean differences in Hu scores for recognizing the seven emotions between the unmasked and masked conditions (Photo/Picture credit: Original).

5. Discussion and Suggestion

5.1. Summary of Results

This study investigates the impact of face mask usage on emotion recognition. It was hypothesized that Hu would significantly decrease with mask-wearing than without masks. The current results supported this hypothesis. Additionally, it was expected that disgust and happiness, which were primarily linked to the lower part of the face, would show a more significant decrease in Hu under masked conditions, while other emotions (e.g., anger, fear, neutrality, sadness, and surprise) would show insignificant changes. Nevertheless, this hypothesis received limited support, as all emotions exhibited a notable decline in Hu.

5.2. Comparison with Previous Research

The present data indicates that when individuals wear face coverings, their ability to recognize emotions is substantially impaired relative to circumstances where masks were not utilized. These conclusions mirror the studies carried out by Carbon and Tsantani et al. [4, 5]. The present study expanded upon prior findings using a sample from the Asian community. Incorporating an Asian population sample augments the cross-cultural validity of the findings, as most previous studies mainly concentrated on Western populations. In line with Western reports like those published by Grenville and Dwyer and Parada-Fernández et al., certain facial expressions such as disgust, happiness, and sadness were found to be profoundly influenced by covering with masks [6,7]. However, unlike some Western research, this study observed that anger and fear displayed significant

differences in identifying emotions when deciding whether or not masks were being worn. Such variations might point towards dissimilarities in how cultures express and perceive emotions, underscoring the necessity of taking into account diverse social contexts within studies.

The finding that masks significantly affect the interpretation of happiness and disgust supports the theory that recognizing facial expressions relies on features of the lower configuration of the face. Nonetheless, the present experiment revealed a significant effect on each emotion, aligning with the result by McCrackin et al. [14]. Moreover, present observations differed from the studies that measured raw accuracy [8]. It may indicate the efficacy of Hu. If the possibility of bias were considered, the outcome would indicate a more significant impact of mask usage. Not only could the ability to recognize emotions that are strongly linked to lower facial expressions be affected, but those less reliant on this area of the face might be affected as well.

Additionally, it is essential to highlight that this experiment occurred during a period when mask-wearing was not customary, in contrast to prior studies. In those earlier studies, wearing a mask was necessary for the COVID-19 period; individuals may get used to recognizing emotions with masks. However, there was no obligation to wear a mask during the present study, and learning the mask faces was not involved. Therefore, participants may have been unfamiliar with recognizing facial expressions with masks. Hsiao et al. found that when the facial patterns used in learning and testing are matched (e.g., both learning and testing involve masked faces), the ability to recognize emotions is higher than when they are mismatched [16]. Therefore, the variability in mask-wearing practices across different periods and settings may significantly affect the generalizability of findings in studies on masked emotion recognition.

5.3. Conclusions and Implications

The present study demonstrates that mask usage considerably affects the precision of emotion recognition. This discovery corresponds with the function of various facial features in emotion detection and further emphasizes the significance of the lower face region in expressing specific emotions. Additionally, our study observed that the capacity to identify all emotions was considerably impaired. It indicates that the masking effect is not confined to particular emotions but substantially influences overall emotion detection. This discovery has significant implications for comprehending the broader effects of mask usage in social interactions.

5.4. Suggestions for Future Research

A limitation of current research exists. The current study does not entirely emulate real-world settings. Bassili found that emotion recognition is a continuous process integrating contextual inputs and dynamic facial muscular movements [17]. However, this study used photographs without motion, which was inconsistent with the condition of real-world conversation. Therefore, the generalizability of our findings is consequently unknown. Subsequent research could focus on the influence of covering by masks on identifying facial expressions in both real-world interactions and video-based observations.

6. Conclusion

To summarize, this research sought to investigate how wearing face coverings affects the ability to recognize human emotions. With a sample of 113 Asian participants, their unbiased hit rates were measured by recognizing seven distinct emotional states – anger, disgust, fear, happiness, neutrality, sadness, and surprise across both masked and uncovered facial presentations were measured. These findings revealed that these seven emotions were all significantly impacted by the utilization of masks. Transparent masks are an alternative that might be taken into consideration in therapeutic settings (such as in-person psychotherapy sessions) when virus prevention and precise emotion assessment are crucial.

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