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Social Anxiety and Facial Emotion Recognition with and without Face Mask-Wearing

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This study examined social anxiety and facial emotion recognition with and without face mask-wearing in a social threat situation. A total of 309 adult males and females were screened using the Korean version of the Social Avoidance and Distress Scale (K-SADS) and the Korean version of the Center for Epidemiologic Studies Depression Scale-Revised (K-CES-DR). Of the participants, 56 individuals were divided into the social anxiety and non-social anxiety groups. Both groups were then exposed to threatening social situations. Using the signal detection theory, the sensitivity and cognitive bias in emotion recognition with and without face mask-wearing was examined. Results showed that the social anxiety group had significantly lower perceptual sensitivity and more negative interpretation bias to faces, with or without face masks. Specifically, the perceptual sensitivity was significantly lower to faces with masks; however, there was no significant difference in interpretation bias. Although both groups showed no significant difference in reaction time with the emotional expression on masked faces, the social anxiety group responded faster to faces wearing masks. As this is the first prospective study to investigate facial emotion recognition with face mask-wearing related to social anxiety, it provides valuable insight and data for future research.

Keywords: social anxiety, COVID-19, face mask-wearing, emotion recognition, signal detection theory

Introduction

The World Health Organization (2020) has called the COVID-19 pandemic an "unprecedented mental health crisis" (n.p.). Due to the ongoing fear of COVID-19 infection and the heavy social atmosphere, the proportion of people at risk of anxiety disorders in Korea has exceeded 12.7% (Lee, 2021), which is about 3.3 times higher than the proportion of people at risk in 2018 before the outbreak of COVID-19 (Ministry of Health and Welfare, Central Disease Control Headquarters, 2019). In particular, the prevalence rates of subtypes of anxiety disorders, such as social anxiety disorder and panic disorder, have increased by 1.68% and 0.94%, respectively, compared to the period before COVID-19 (Winkler et al., 2021).

Among them, social anxiety (SA) disorder's characteristics include avoiding social situations involving interaction with others due to fear of being judged by others. Despite COVID-19 social distancing measures reducing human density, prevalence and symptoms of SA disorder have paradoxically increased. Social distancing limits direct social interaction, potentially reducing awareness of negative beliefs about self, others, and social events (Clark & Wells, 1995). Cognitive biases, such as attentional and interpretive biases (Rapee & Heimberg, 1997), likely contribute to onset and persistence of SA.

Facial expressions are key in studying attentional and interpretational biases in SA, serving as cues for observing others' reactions in social situations. According to numerous studies, individuals with SA perceive negative expressions (anger, disgust) as well as ambiguous emotional valence more quickly than the non-socially anxious

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(NSA) group (Mogg & Bradley, 2005; Miskovic & Schmidt, 2012). Additionally, they tend to evaluate these expressions more negatively (Amir et al., 2010). Negative facial expressions, as visual stimuli implying criticism and rejection, trigger fear of negative evaluation in SA (Gutiérrez-García & Calvo, 2017). This can be explained by cognitive content-specificity hypothesis, which posits that the mood of an individual is biased towards stimuli that align with their cognitive content (Clark & Beck, 1989). Therefore, individuals with SA tend to perceive social treat cue more rapidly, resulting in negative evaluations as they miss opportunities objectively appraise such threat cues (Chen et al., 2002). Individuals with SA perceive ambiguous facial expressions with uncertain valence of emotion more quickly than the general population (Miskovic & Schmidt, 2012), interpreting them negatively (Maoz et al., 2016). In this context, ambiguous facial expressions refer to facial expressions mixed with different emotions, making neutral facial expressions more easily perceived as ambiguous (Wallbott, 1988). Thus, individuals with SA tend to react more quickly and interpret neutral or ambiguous facial expressions more negatively than the general population, showing a tendency to perceive more anger (Bell et al., 2011).

Since COVID-19, indoor and outdoor face mask wearing has become mandatory worldwide. However, recent research suggests that recognizing emotions in masked faces decreases by approximately 15%, with reduced confidence in judgments (Freud et al., 2020; Carbon, 2020). Face masks disrupt holistic processing of facial features (Mauer et al., 2002). For instance, Jung and Sun (2017) showed difficulties in discerning emotions when the mouth area was obscured, hindering integration of facial features. In this context, face masks themselves have ambiguous properties that limit important clues for recognizing emotions in the face.

While there is no concrete mechanism for how SA individuals focus on and interpret faces wearing masks, we can infer from these individuals' perceptual and cognitive characteristics. First, with prolonged mask wearing during COVID-19, people rely more on information from the exposed areas like the eyes and eyebrows (Barrick et al., 2021). However, SA individuals tend to avoid eye contact more than NSA individuals, as shown by Baron-Cohen et al. (1997) in the Reading the Mind in the Eyes Test (RMFT). Consequently, accurately perceiving and interpreting emotions through the eyes, the only visible area on masked faces, may pose challenges for SA individuals. Second, Given the ambiguity of face masks and SA individuals' difficulty inferring emotions through eye contact, recognizing emotions in masked faces leads to heightened confusion and perceived threat, thus increasing the likelihood of selective attention and negative interpretation biases.

However, there is a limit to discerning whether SA's bias toward recognizing emotional expressions in faces wearing masks is due to sensitivity in identifying emotional stimuli accurately or a tendency to interpret emotional triggers negatively. In this context, signal detection theory, which examines an individual's perceptual sensitivity (d') and response criterion (c), can help address this issue (Green & Swets, 1966). Perceptual sensitivity measures the accuracy of discriminating stimuli, with high sensitivity indicating strong discernment and low sensitivity indicating reduced capability. The response criterion reflects an individual's tendency towards a specific response, shedding light on interpretive biases. In this study, a response criterion value of 0 denotes no bias, positive values indicate a neutral interpretation, and negative values suggest a negative emotional bias.

Previous studies on attention and interpretation bias towards facial expressions in individuals with SA have been solely based on basic facial expressions without considering face mask-wearing. Therefore, this study aims to expand research by considering the normalization of masks during COVID-19. Thus, this study uses an experimental paradigm based on signal detection theory to clarify whether the difference in biases between SA and NSA groups regarding the facial perception of individuals with masks relates to perceptual or cognitive factors. We tested the following hypotheses: 1) The SA group exhibits different sensitivity and response criteria to emotions on faces compared to the NSA group, regardless of mask-wearing. 2) The SA group demonstrates different sensitivity and response criteria to emotions on faces wearing masks compared to faces without masks, in contrast to the NSA group. 3) The SA group displays different reaction times to emotions on faces wearing masks compared to faces without masks, compared to the NSA group.

Methods

Participants

The present study administered the Korean version of the Social

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Avoidance and Distress Scale (K-SADS) and the Korean version of the Center for Epidemiologic Studies Depression Scale-Revised (K-CESD-R) scale to 309 adults recruited online or on a university campus. The SA group comprised the top 15% (91 points or higher) of K-SADS scores, while the NSA group comprised the bottom 15% (62 points or lower). Participants with K-CESD-R scores below the clinical cutoff of 13 points were included to differentiate depression. Sixty participants meeting the inclusion criteria agreed to participate. After excluding four individuals who withdrew, 56 participants remained for analysis.

Measures

Korean Version of the Social Avoidance and Distress Scale (K–SADS)

Watson and Friend (1969) developed the Social Avoidance and Distress Scale (SADS), later translated into Korean by Lee and Choi (1997). This self-report measure assesses social anxiety and distress across various social situations and avoidance of distressing conditions. The 28-item questionnaire uses a Likert scale (0-8), with higher scores indicating greater social avoidance and distress. Cronbach's alpha for this study was .95.

Korean Version of Center for Epidemiologic Studies Depression Scale–Revised (K–CESD–R)

The Korean version of the CESD-R, based on the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders (DSM-5), comprises nine symptom groups. Originally developed by Radloff (1977), it was translated into Korean by Lee et al. (2016). The instrument queries a patient's various symptoms of depression over the past week, where higher scores denote higher depression levels. The 20-item questionnaire uses a Likert scale from 0 (less than 1 day) to 4 (nearly every day for 2 weeks), assessing the frequency of depressive symptoms over the past week. The Cronbach's alpha in this study was .94.

Emotion recognition task

We used facial stimuli from the Yonsei Face Database (Chung et al., 2019) in the emotion recognition task. The mask wearing status and emotional type were randomized across all participants, thereby mitigating any potential order effects. The procedure was conducted as follows. First, a fixation point (+) was displayed at the center of the monitor for 500 ms to facilitate attentional focus. Second, after the fixation point disappeared, a facial stimulus appeared for 40 ms. Third, after the facial stimulus disappeared, the participant saw a blank screen for 77 ms, followed by a mask stimulus of the same size as the facial stimulus for 100 ms. Thus, the interval between the photo stimulus and mask stimulus appearance was 117 ms. Finally, during the blank screen with only the fixation point, participants were prompted to respond using the computer keyboard (z = *anger*, m = *no anger*) to indicate whether the face displayed angry (z) or not angry (m). The subsequent trial commenced after a 500 ms interval, with an emphasis on response accuracy over speed.

Procedure

As participants entered the laboratory, they were given a cover story about a study on "College Students' Information Processing Styles and Emotional Recognition" to conceal the true purpose of the study, and asked to sign the consent form. To induce anxiety, participants were instructed to deliver a five-minute presentation on a topic of their choice in front of a smart device with the recorded presentations to be assessed by the researchers. Following three minutes of preparation, participants were directed to proceed with the facial emotion recognition task first. After completing the task, participants were individually debriefed with explanations about the study and compensation for their participation. The procedure lasted approximately 15-20 minutes.

Data Analysis

We used IBM SPSS Statistics 26.0 to analyze the raw data of 56 participants. We calculated the internal consistency to examine the measurement tools' reliability. Descriptive statistics, χ^2 tests and independent *t*-tests verified the homogeneity and demographic characteristics between the groups. Furthermore, we conducted a two-way repeated measures ANOVA to examine the sensitivity and response criterion differences in emotion recognition according to

1) In the facial emotion recognition task, we collected participants' responses, calculated hit rate (H) and false alarm rate (FA), and converted them into z-scores. Sensitivity (d') was derived from z(H) - z(FA), while response criterion (c) was determined as (-1) × [z(H) + z(FA)] (Macmillan & Creelman, 2004; Stanislaw & Todorov, 1999).

mask-wearing status using signal detection theory[1]. Lastly, we did a three-way repeated measures ANOVA to investigate the differences in reaction time for facial expression recognition based on mask-wearing status and emotion type.

Results

Descriptive Statistics

There were no significant differences between groups in terms of gender and age (gender: $\chi^2 = .11$, *ns*, age: $t_{(54)} = -1.35$, *ns*).

Group differences in sensitivity and response criteria for emotion recognition

Based on the hit and false alarm rates (Table 1), Table 2 presents the mean and standard deviation values of group differences in sensitivity and response criteria for facial emotion recognition, categorized by mask-wearing status.

Group differences in sensitivity and response criteria for emotion recognition based on mask–wearing status

For sensitivity criteria, the main effects of group ($F_{(1,54)} = 4.43$, $p < .05$) and mask-wearing status ($F_{(1,54)} = 14.26$, $p < .001$) were significant, but the interaction effect was not significant ($F_{(1,54)} = .51$, *ns*). For the response criteria, the main effect of the group was significant ($F_{(1,54)} = 5.07$, $p < .05$), but the main effect of mask-wearing status ($F_{(1,54)} = .69$, *ns*) and the interaction effect between group and mask-wearing status ($F_{(1,54)} = .14$, *ns*) were not significant.

Group differences in reaction time for mask–wearing status and emotion type

We minimized the influence of outliers by using the median as the representative reaction time value for each individual's correct rejection and hit trials. The results of the analysis on the difference in reaction time among groups based on mask-wearing status and emotion type showed that the main effects of group ($F_{(1,54)} = 5.28$,

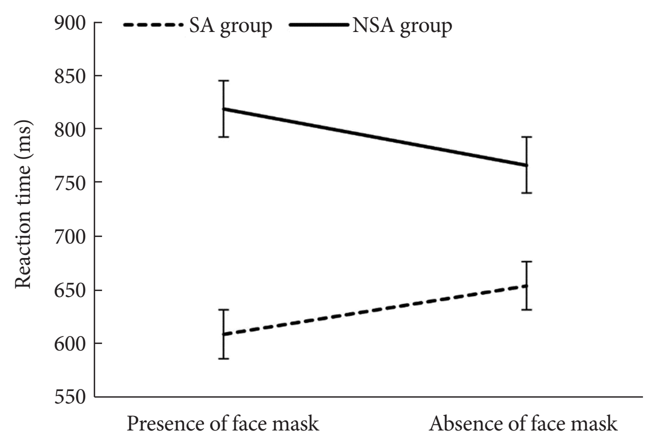

Figure 1. *The interaction effect between mask-wearing status and group. Error bars represent the standard error of the mean.*

Table 1. *The Mean and Standard Deviation Values of Hit Rates, False Alarm Rates, Miss Rates, and Correct Rejection Rates*

		SA Group	NSA Group
Presence of a face mask	Hit rates	.81 (.06)	.82 (.03)
	False alarm rates	.28 (.08)	.06 (.08)
	Miss rates	.19 (.06)	.18 (.03)
	Correct rejection rates	.72 (.08)	.94 (.08)
Absence of a face mask	Hit rates	.84 (.05)	.83 (.06)
	False alarm rates	.17 (.09)	.05 (.05)
	Miss rates	.16 (.05)	.17 (.06)
	Correct rejection rates	.83 (.09)	.95 (.05)

SA = social anxiety; NSA = non-social anxiety.

Table 2. *The Means and Standard Deviations of Group Differences in Sensitivity and Response Criteria in Facial Emotion Recognition*

	SA Group		NSA Group	
	Sensitivity	Response criteria	Sensitivity	Response criteria
Presence of a face mask	1.50 (.62)	-.14 (.28)	1.96 (.81)	.04 (.44)
Absence of a face mask	2.24 (.66)	-.07 (.24)	2.30 (.75)	.07 (.39)

SA = social anxiety; NSA = non-social anxiety.

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$p < .05$) and emotion type ($F_{(1,54)} = 37.31$, $p < .001$) were significant. However, mask-wearing status was not ($F_{(1,54)} = .22$, *ns*). There was a significant interaction effect between mask-wearing status and group ($F_{(1,54)} = 43.45$, $p < .001$) (Figure 1), but not between emotion type and group ($F_{(1,54)} = 1.41$, *ns*) or between mask-wearing status and emotion type ($F_{(1,54)} = 1.04$, *ns*). Moreover, the three-way interaction effect between the group, mask-wearing status, and emotion type was not significant ($F_{(1,54)} = .22$, *ns*). As a result of the significant interaction effect between the group and mask-wearing status, simple main effect analysis showed that the SA group had faster reaction times (609.54) to faces wearing masks compared to faces without masks (655.05). On the other hand, the NSA group had a slower reaction time (820.40) to faces wearing masks compared to faces without masks (767.85). It reveals opposite trends between the two groups.

Discussion

The main results are as follows. First, we found significant differences between groups in sensitivity and response criteria for facial emotion recognition regardless of mask-wearing. Regarding sensitivity, the SA group showed lower sensitivity to emotions on faces, regardless of whether the face was wearing a mask, compared to the NSA group. The SA group had relatively higher false alarm rates regardless of mask-wearing than the NSA group. This finding is intriguing as Cooney et al. (2006) noted challenges for SA individuals in differentiating neutral from negative expressions, like anger. From an evolutionary perspective, faces signaling potential danger trigger avoidance or escape responses. Yet, neutral faces lack clear emotional cues for predicting survival-related fear responses. Despite not being explicit threats, they can still serve as implicit danger signals (Dugas et al., 2005). In the case of SA individuals, one can perceive ambiguous stimuli that do not elicit warning responses as threatening. We also observed a significant main effect of mask-wearing status on sensitivity. This aligns with previous research showing a notable decrease in emotion recognition accuracy for masked faces compared to unmasked ones. Specifically, sensitivity to emotions was notably lower for masked faces compared to unmasked ones, suggesting difficulty in accurately perceiving emotions on masked faces due to facial restrictions.

On the other hand, the SA group was biased in interpreting facial expressions more negatively than the NSA group, regardless of mask-wearing, attributed to lower response criteria in facial expression recognition. This study's findings align with Kim and Yang's (2022) research, indicating cognitive biases in facial stimulus interpretation among SA individuals. Those with high SA tend to excessively focus on social perceptions, comparing their performance and often evaluating themselves negatively. Thus, in situations triggering social threat, like presenting assignments, SA individuals tend to interpret facial expressions with a negative bias, regardless if one wears a face mask.

Second, no significant interaction effect was observed between group and mask-wearing status on sensitivity and response criterion for facial emotion recognition. This can be elucidated by comparing the effect sizes of the main factors on the measured variables. For sensitivity, the group (5.77) and mask-wearing status (3.02) showed a large effect. Similarly, the group (3.10) and mask-wearing status (1.04) showed a large effect on the response criterion. Considering the large effect sizes observed for both group and mask-wearing status, an additive effect is evident rather than an interaction effect on sensitivity and response criterion.

Lastly, a significant main effect of emotion type on reaction time to facial expressions was observed. We found a faster response to angry expressions than to neutral expressions. This result is consistent with previous research that people perceive anger more quickly than neutral emotions (Ekman & Friesen, 1984). From an evolutionary perspective, rapidly perceiving anger, which conveys negative emotions associated with threats, is vital for enhancing human survival chances. Even today, angry expressions appear to be more salient, capturing people's attention more effectively than other expressions.

In addition, the SA group demonstrated faster response times to facial stimuli, regardless of mask presence, compared to the NSA group. As SA levels increase, individuals tend to react more sensitively to facial stimuli than to visual stimuli, such as everyday objects (Garner et al., 2006). People with SA tend to create mental representations of themselves in social situations, selectively attending to external threats perceived as negative evaluations. Hence, SA's cognitive traits of quickly attending to faces conveying others' intentions or evaluations can explain this phenomenon.

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In particular, the SA group showed a faster reaction time to faces wearing masks than faces without masks, while the NSA group showed a faster reaction time to faces without masks than those with masks. These results support the cognitive content-specificity hypothesis, suggesting that anxiety arises from cognitive content focused on themes of threat, unpredictability, and ambiguity. Specifically, the individuals with SA tend to exhibit faster attention towards social information (Bar-Haim et al., 2007), leading to faster perception of faces wearing masks, which introduce ambiguity. Conversely, the NSA group appears to take longer to react to masked faces, possibly to make more accurate judgments of the emotions portrayed. This delayed reaction may stem from reduced perception and intensity of emotions caused by mask-wearing. Therefore, the disparity in reaction times to masked and unmasked faces reflects the distinct characteristics of the two groups.

The study has the following research significance. First, the present study is the first one, domestically and internationally, to examine the characteristics of facial emotion recognition based on mask-wearing status with symptoms of SA. This study provides empirical evidence on the impact of mask-wearing on facial emotion recognition in the "with COVID-19" era, contributing to the exploration of changes and new phenomena arising from the pandemic. Second, this study enriches the literature on signal detection theory since it used the approach to analyze the emotional recognition biases of faces depending on mask-wearing status among the SA group, divided into perception and cognitive characteristics. Third, this study provides fundamental data for in-depth understanding and treatment of emotion recognition of faces with masks among the SA group. The SA group may negatively affect interpersonal relationships by accepting and responding to neutral expressions on masked faces as negative evaluations of themselves. Therefore, therapeutic interventions focusing on sensitivity would be effective in enhancing their adaptive responses. For example, facial affect recognition intervention, involving gradual exposure to low-intensity emotions, enhances sensitivity to emotions on faces with masks. This intervention can assist the people with SA in functioning adaptively in social situations.

The suggestions for limitations and follow-up studies of this study are as follows. First, participant selection for the SA group relied solely on K-SADS scores, commonly used but not diagnostic of SA disorder. Future research should target clinical groups diagnosed using structured clinical interviews like the SCID. Furthermore, this study presented stimuli consisting of a single dimension of negative and neutral emotions, lacking the complexity of real-world social situations. As the cognitive bias of SA is also associated with a tendency to avoid or devalue positive stimuli, future studies should analyze how sensitivity and cognitive bias patterns vary across multidimensional emotions according to SA symptoms.

Despite these limitations, this study's findings offer insights into the biases of the SA group in recognizing facial emotions with masks. This finding can aid preparation for situations requiring mask-wearing to safeguard against air pollution (e.g., high concentrations of fine dust) and diseases post-COVID-19. Additionally, researchers can utilize these results as foundational data for developing effective preventive and therapeutic interventions.

Author contributions statement

GRK, graduate student at Chung-Ang University who is now a clinical psychology intern at Dong-A University Hospital, designed the study, conceptualized the research, collected and analyzed the data, and wrote the manuscript draft.

MHH, a professor at Chung-Ang University, supervised the research process and reviewed the manuscript. All authors provided critical feedback, participated in the revision of the manuscript, and approved the manuscript.

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