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ORIGINAL PAPER

The Effect of Face Masks and Sunglasses on Emotion Perception over Two Years of the COVID-19 Pandemic

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Abstract
Since the beginning of the COVID-19 pandemic in early 2020, face masks have become a common experience for many people to reduce the spread of the disease. Although recent research has shown that face masks impair emotion recognition, it is unclear how this impairment differs from other familiar types of face covering, such as sunglasses. In the present study, participants identified expressions and rated their confidence in this assessment of six affective expressions (anger, disgust, fear, surprise, sadness, and happiness) on faces wearing masks or sunglasses at four different time points during the pandemic (June 2020, March 2021, September 2021, June 2022). They also provided judgements of emotion intensity and genuineness. Overall, emotion identification of faces with masks was less accurate and had lower ratings of confidence and emotion intensity than faces with sunglasses. Faces with sunglasses, alternatively, were rated as less genuine than faces with masks. Furthermore, this pattern for both masks and sunglasses remained stable across two years of the pandemic. This study provides new insights on the differential effects of face masks and sunglasses on emotion perception and highlights the importance of face coverings for emotion communication and social interactions.

Keywords Facial expression · Emotion · Genuineness · Face masks · Sunglasses

Introduction

In response to the COVID-19 pandemic, the governments of many countries strongly recommended or mandated the use of face masks to mitigate the spread of the disease. Although masks provide substantial public health benefits (Howard et al., 2021; Leung et al., 2020; Prather et al., 2020), they may impair social interactions by reducing emotion recognition (Carbon, 2020). While much has been written about the impact of masks during the pandemic (e.g., Freud et al., 2020; Howard, 2021; Ramachandra & Longacre, 2022), it is notable that there are relatively few reports on the negative effects on face

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perception of other accessories that cover the face, such as sunglasses. Although both types of face coverings conceal features of the face that are important in the identification of particular emotions, the specific features covered are distinct—with masks obscuring the mouth and nose and sunglasses obscuring the eyes. In the present research, we examined the impact of both face masks and sunglasses on emotion perception.

Facial Features and Emotion Perception

Facial expressions are a complex interplay of various facial muscle movements that convey a range of emotions (Ekman et al., 2002). To identify which areas of the face are involved in emotion recognition, previous studies have employed diverse methodological approaches. To explore the relationship between eye movements and emotion recognition in full-face conditions, researchers have used eye trackers (Friesen et al., 2019). For instance, Schurgin et al. (2014) conducted a study where participants viewed six blocks of trials while their eye movements were recorded. Each block consisted of trials displaying a neutral expression or one specific emotion (anger, fear, sadness, shame, disgust, or happiness) at varying intensities. Participants were asked to determine whether the expression was neutral or depicted an emotion by pressing the appropriate button. Analyzing the first four fixations revealed that participants paid more attention to areas of interest (AOIs) indicative of the emotion intended by the face. Specifically, they focused longer on the eyes of faces displaying anger, fear, sadness, and shame, while directing more attention to the upper lip of faces expressing disgust and happiness. Similarly, other studies have demonstrated that attention is primarily directed toward areas related to the mouth when perceiving happiness, whereas a focus on areas related to the eyes has been observed for fearful faces (Eisenbarth & Alpers, 2011; Gamer & Büchel, 2009; Vetter et al., 2019). However, in a recent meta-analysis, Grainger and Henry (2020) found no significant correlations between gaze fixation on areas related to either the eye or mouth and recognition accuracy for all basic emotions.

To further investigate the relationship between facial features and emotion recognition, researchers have presented partial facial features (Friesen et al., 2019). Calder et al. (2000), for example, conducted a study where participants were shown either the upper or lower half of the face and were asked to identify the expressed emotion. The results indicated that anger, fear, and sadness were better recognized in the upper half of the face, while happiness and disgust were better recognized in the lower half. Expressions of surprise were equally recognizable from both the top and bottom sections of the face. Furthermore, researchers have employed partial face occlusion when examining emotion recognition. For example, Schurgin et al. (2014) used a black strip to cover either the eye or mouth region to determine which area was more critical for expression recognition. In contrast to Calder et al.'s (2000) findings, the results showed that anger was better recognized from the eye area, while happiness and disgust were better recognized from the mouth area. Notably, fear and sadness were equally recognizable from both the eye and mouth areas.

Another frequently used method is the Bubbles technique, where researchers apply random bubbles to emotional faces and ask participants to categorize the emotions (Gosselin & Schyns, 2001; Smith et al., 2005). The goal of this technique is to identify the diagnostic visual information for categorization emotion. The results suggested that information from the eye region was crucial for recognizing angry and fearful expressions, while information from the mouth region was essential for recognizing happy, disgusted, and surprised expressions. In contrast, both eye and mouth regions were equally important for recognizing sad expressions.

Taken together, it remains largely unclear which specific facial regions are crucial for recognizing specific emotions. Although there is some evidence that the eyes are important for anger and the mouth is important for happiness and disgust, this research is not consistently supported by eye tracking data and further research is necessary to explore the intricate relationship between facial regions or features and the perception of emotions.

Impact of Masks and Sunglasses on Emotion Perception

Since the outbreak of COVID-19, an increasing number of studies have explored the effects of face masks on emotion perception. In contrast to previous research that often presented only partial areas of the face or that covered features with black strips (but see Kret & Gelder, 2012; Kret et al., 2021), this form of occlusion was increasingly common during COVID-19 in people's everyday lives. Notably, research related to face masks during that time indicated that in general perceivers generally exhibit lower overall recognition accuracy for facial expressions on masked compared to unmasked faces (for reviews, see Pavlova & Sokolov, 2022; Ramdani et al., 2022). For example, Carbon (2020) found that recognition for anger, disgust, happiness, and sadness was lower for masked than unmasked faces, although no differences emerged for fear and neutral expressions. In contrast, Grahlow et al. (2022) reported that masks significantly reduced recognition of anger, sadness, and disgust, but had no effect on the recognition of happiness, fear, and neutral expressions. Notably, masks have not only been shown to impact recognition accuracy but also the perceived intensity of emotions. For example, Li et al. (2023) and Tsantani et al. (2022) found that masks reduced the perceived intensity of all basic emotions, with the occasional exception of anger (Tsantani et al., 2022). Interestingly, Li et al. (2023) found that masks increased the perceived intensity of fear.

Besides masks, another common form of face covering are sunglasses. Since emotional information is distributed not only around the lower parts of the face, but also around the upper parts, especially the eyes (Ekman et al., 2002), the absence of information from this area can impair emotion recognition. Surprisingly, few studies have examined the effect of sunglasses on emotion perception. Two recent studies that investigated the effects of both sunglasses and masks on emotion perception during COVID-19 pandemic, however, are the exception. Noyes et al. (2021) found that participants in the United Kingdom exhibited lower recognition accuracy for all basic emotions, except sadness and anger, for faces with masks compared to sunglasses. In contrast, recognition was lower for faces with sunglasses than masks for sadness, while no significant difference in recognition accuracy was observed for anger. In contrast, Kim et al. (2022) found that participants in Korea showed lower recognition accuracy for all basic emotions, except fear, for faces with masks compared to sunglasses. Notably, no difference in recognition accuracy between masks and sunglasses was found for fear. Together these studies indicate that the impact of masks on emotion recognition may be generally greater than that of sunglasses.

While masks compared to sunglasses may have a more detrimental effect on the recognition of facial expressions, sunglasses may have a more negative impact on the perceived genuineness of facial expressions. Previous research has shown that the eyes play a crucial role in the perception of emotional authenticity (Ekman & Friesen, 1982; Gosselin et al., 2002; Krumhuber & Manstead, 2009). For example, studies have found that smiles involving the Duchenne marker, activation of muscles around the eyes causing crow's feet, are perceived as more genuine than smiles without the Duchenne marker (Gunnery & Ruben, 2016; Quadflieg et al., 2013). Recent studies have also shown that the Duchenne marker

may be an important indicator of emotional genuineness in expressions of sadness (Malek et al., 2019; but see Miller et al., 2022). Therefore, we predict that sunglasses may have a greater negative impact on the perceived genuineness of facial expressions compared to face masks.

Another key difference between masks and sunglasses is familiarity. Whereas sunglasses have been a popular fashion accessory for decades, widespread mask-wearing only began in most countries (with the exception of some East Asian countries) in 2020 during the COVID-19 pandemic (Johns, 2020). North Americans, therefore, have lower familiarity with face masks than with sunglasses. Importantly, familiarity may affect people's use of specific facial features as cues. For example, in a recent study by Barrick et al. (2021), participants who reported having frequent interpersonal contact with individuals wearing masks were more likely to use cues from the eyes. It is therefore possible that as the threat of COVID-19 continued and people became more familiar with wearing masks and being exposed to others wearing masks, they may have grown increasingly adept at using cues from other areas not related to the lower face in emotion recognition. Conversely, given that people are already very familiar with sunglasses, their ability to interpret facial expressions when others wear this accessory is not expected to change during the pandemic.

The Present Research

The present study sought to examine how face masks and sunglasses, impact emotion perception and whether their effects change over time. By investigating the effects of these two common, everyday forms of facial coverings, one that has long been familiar (sunglasses) and one that grew increasing familiar during the pandemic (face masks), this research provides new information on how different forms of facial occlusions affect our ability to recognize six basic emotions, including anger, disgust, fear, surprise, sadness, and happiness, as well as the potential effects of familiarity in this process.

To achieve these objectives, we collected data from four groups of Canadian participants from June 2022 until June 2022, at time periods that coincided with important events during the pandemic. In particular, we recruited these participants at 2 months (T1), 8 months (T2), 14 months (T3), and 27 months (T4) months after the introduction of a mask mandate by the Public Health Agency of Canada (PHAC) in April 2020. Participants were asked to categorize six emotional expressions displayed on faces wearing either masks or sunglasses, and to rate their level of confidence in making this judgment, as well as the intensity and genuineness of the emotional expressions. Notably, at T4, participants were also asked to make the same judgments for faces without masks or sunglasses. The inclusion of multiple measures was intended to capture the complexity of emotion perception within this unique social context. While the categorization of emotional expressions forms the core of the study, the confidence, intensity, and genuineness ratings offer deeper insights into the participants' emotional processing. Through these complementary perspectives, we aimed to provide a comprehensive and nuanced understanding of the impact of masks and sunglasses on emotion perception.

Although mask mandates related to COVID-19 pandemic were lifted in June 2022 and the wearing of face masks is no longer a common practice in most Western countries, our study presents a critical snapshot of this pivotal period. In addition to providing further data that is necessary to add to the discussion about how different facial features such as the eyes and the mouth facilitate the recognition of a variety of emotions, our results related to two common types of facial coverings—masks and sunglasses—also offer insights relevant

to preparing for future pandemics. According to the director general of the World Health Organization (WHO), countries across the globe should prepare for the next pandemic that could be worse than COVID-19 (Chasen, 2023). As noted by Dr. Tedros Adhanom Ghebreyesus, "When the next pandemic comes knocking — and it will — we must be ready to answer decisively, collectively and equitably." One way to be ready to is to understand how effective strategies in reducing the spread of such pathogens, such as wearing masks (Howard et al., 2021), can change over time processes fundamental to human interactions such as emotion identification.

Method

Transparency and Openness

In this article, in accordance with JARS (Appelbaum et al., 2018), we report how we determined our sample size, all data exclusions, all manipulations, and all measures in the experiment. Although all data and analysis code are available at https://osf.io/xc6fz/, the design and analysis method of this research were not pre-registered.

Participants

A total of 375 students were recruited from a university in Ontario, Canada, across four different time points and received course credit for their participation. For a comprehensive overview of detailed information about the participants see Table 1. A sensitivity analysis using G*Power (Faul et al., 2007) showed that our final sample size could detect an effect size of $f = 0.145$ ($\eta_p^2 = 0.02$) for the critical main effect of Face Covering (power = 0.80, $\alpha = 0.05$).

Stimuli

The stimuli consisted of 4 White Caucasian models (2 men and 2 women) with emotional faces from the Amsterdam Dynamic Facial Expression Set (ADFES; van Der Schalk et al., 2011). Using photoshop, we applied a pair of sunglasses and a black face mask to each face respectively (see Fig. 1). A total of 48 stimuli (4 models × 6 emotions × 2 face covering) were created for waves T1, T2 and T3. In wave T4, in addition to these 48 stimuli, 24 faces without masks or sunglasses were also included.

Procedure

Using a Qualtrics survey platform (www.qualtrics.com), participants were informed that they would be presented with a series of images and their task was to judge the emotional facial expressions. On each trial, participants were presented with a photograph accompanied by four sequential questions displayed below the image. For the first question, "What emotion do you infer from the face?", participants were presented with six emotion options (anger, disgust, fear, happiness, sadness, surprise), a neutral option, and a "none of the above" option and instructed to select one response. For the other three questions, "How confident are you about your judgement?", "What intensity is the expression?", and "How

Table 1 Mask mandates in Ontario and demographic information of participants at four time points

Time	Months after the implementation of the Mask mandate	*N*	Mean age (*SD*)	Gender distribution	Ethinicity distribution	# Participants born in Canada
T1						
June 14, 2020 June 23, 2020	2	88	20.63(3.16)	21 M, 67F	25 White, 7 East Asian, 8 South East Asian, 27 South Asian, 10 Black, 3 Middle Eastern, 8 other ethnicity	85
T2						
March 4, 2021 March 23, 2021	11	93	20.15(4.24)	40 M, 53F	19 White, 4 East Asian, 7 South East Asian, 33 South Asian, 18 Black, 7 Middle Eastern, 5 other ethnicity	87
T3						
September 12, 2021 September 25, 2021	16	93	19.05(3.53)	17 M, 76F	26 White, 11 East Asian, 8 South East Asian, 24 South Asian, 11 Black, 7 Middle Eastern, 6 other ethnicity	91
T4						
June 24, 2022 July 8, 2022	25	101	18.79(3.00)	17 M, 84F	32 White, 8 East Asian, 7 South East Asian, 28 South Asian, 10 Black, 8 Middle Eastern, 8 other ethnicity	100

The mask mandate was lifted on June 11, 2022. At T1, 93 students were originally recruited, but five participants who have not finished the whole experiment were excluded from the analyses. At T3, 95 students were originally recruited, but two participants who have not finished the whole experiment were excluded from the analyses

Fig. 1 Examples of six emotional faces with and without masks and sunglasses. *Note*: T1, T2, and T3 employed materials featuring models wearing masks and sunglasses, while T4 utilized materials with models wearing masks, sunglasses, and uncovered faces

genuine is the expression?", participants were instructed to move a slider ranging from 0 (not at all confident/intense/genuine) to 100 (extremely confident/intense/genuine), to indicate their response. Each participant completed a total of 48 randomized trials that included 12 trials for each of the four models, with two different types of face coverings (i.e., mask vs. sunglasses) and six emotions (i.e., anger, disgust, fear, happiness, sadness, surprise). This data was collected at three time points, T1, T2, and T3. At T4, participants completed the same 48 trials in the first block, followed by an additional six trials (one for each emotion) for each of the four models without any face coverings in the second block.

Results

Comparing Faces with Masks and Sunglasses on Emotion Perception Across Time

To test whether the effects of face masks vs. sunglasses change over time, we used R (version 4.1.0; R Core Team, 2020) with ez (version 4.4–0; Lawrence, 2016) to perform a 2 (Face Covering: Sunglasses, Masks)×6 (Emotion: Anger, Disgust, Fear, Happiness, Sadness, Surprise)×4 (Time: T1, T2, T3, T4) mixed-design ANOVA analysis on recognition accuracy, confidence, intensity, and genuineness ratings, respectively. The emotion

recognition scores represent the percentage of times the participant correctly recognized each emotional expression across all models for each face covering condition. The scores for confidence, intensity, and genuineness represent the average evaluation of each emotional expression across the four models under each face covering condition. Both Face Covering and Emotion were treated as within-subjects factors, whereas Time was a between-subjects factor. A complete overview of effects can be found in Table 2.

Emotion Recognition Accuracy and Confidence

For emotion recognition accuracy and confidence ratings, the main effects of Face Covering and Emotion were both significant. Importantly, these main effects were qualified by the two-way Face Covering by Emotion interactions while the Face Covering, Emotion, by Time three-way interactions were not significant. Given our primary interest in delineating

Table 2 Mixed-Design ANOVA analysis on the emotion recognition accuracy, confidence, intensity, and genuineness ratings

	Effect	*F*	*df*	*p*	η_p^2
Accuracy	Face covering	1230.58	(1, 371)	**< .001**	0.77
	Emotion	408.41	(5, 1855)	**< .001**	0.52
	Time	2.03	(3, 371)	.110	0.02
	Face covering × Emotion	291.02	(5, 1855)	**< .001**	0.44
	Face covering × Time	2.73	(3, 371)	**.044**	0.02
	Emotion × Time	1.07	(15, 1855)	.377	0.01
	Face covering × Emotion × Time	1.11	(15, 1855)	.343	0.01
Confidence	Face covering	180.52	(1, 371)	**< .001**	0.33
	Emotion	156.65	(5, 1855)	**< .001**	0.30
	Time	1.95	(3, 371)	.120	0.02
	Face covering × Emotion	212.45	(5, 1855)	**< .001**	0.36
	Face covering × Time	0.24	(3, 371)	.869	< 0.01
	Emotion × Time	1.00	(15, 1855)	.452	0.01
	Face covering × Emotion × Time	1.01	(15, 1855)	.446	0.01
Intensity	Face covering	21.39	(1, 371)	**< .001**	0.05
	Emotion	79.46	(5, 1855)	**< .001**	0.18
	Time	1.15	(3, 371)	.331	0.01
	Face covering × Emotion	227.01	(5, 1855)	**< .001**	0.38
	Face covering × Time	3.02	(3, 371)	**.030**	0.02
	Emotion × Time	1.73	(15, 1855)	**.040**	0.01
	Face covering × Emotion × Time	3.96	(15, 1855)	**< .001**	0.03
Genuineness	Face covering	66.56	(1, 371)	**< .001**	0.15
	Emotion	153.54	(5, 1855)	**< .001**	0.29
	Time	1.04	(3, 371)	.373	0.01
	Face covering × Emotion	112.04	(5, 1855)	**< .001**	0.23
	Face covering × Time	1.79	(3, 371)	.148	0.01
	Emotion × Time	1.33	(15, 1855)	.177	0.01
	Face covering × Emotion × Time	1.09	(15, 1855)	.362	0.01

Bold font indicates a significant effect

the differential impact of sunglasses and masks on emotion perception, we disaggregated the significant two-interaction by Face Covering. Table 3 presents the means and standard deviations for all ratings for each emotional expression on faces with sunglasses and masks, as well as the paired-sample *t*-tests related to Face Covering. It is worth noting that an effect was considered significant only if the *p*-value fell below the Bonferroni-adjusted significance level of 0.008 (=0.05/6 comparisons). Overall, participants demonstrated lower accuracy and confidence across all emotional expressions when evaluating faces occluded by masks compared to sunglasses, with the exception of fear. Notably, participants showed reduced accuracy and diminished confidence in their judgements for faces expressing fear with sunglasses compared to masks.

Perceived Emotion Intensity

For perceived emotion intensity, the main effects of Face Covering and Emotion were both significant. Importantly, the two-way Face Covering by Emotion interaction was

Table 3 Mean values, standard deviations, and paired-sample *t*-tests for each rating and emotional expression on faces with sunglasses and masks

	Emotion	Sunglasses	Masks	*t*	*df*	*p*	Cohen's *d*
Accuracy	Anger	84.80(22.74)	59.53(26.19)	17.96	374	**<.001**	1.03
	Disgust	93.07(16.21)	25.80(25.52)	46.57	374	**<.001**	3.15
	Fear	38.40(29.96)	44.67(27.33)	−3.40	374	.001	0.22
	Happiness	97.87(9.44)	72.07(28.76)	17.36	374	**<.001**	1.21
	Sadness	78.60(24.26)	61.93(29.47)	9.87	374	**<.001**	0.62
	Surprise	93.20(14.98)	89.13(17.73)	4.19	374	**<.001**	0.25
Confidence	Anger	75.02(16.42)	68.39(16.82)	9.04	374	**<.001**	0.40
	Disgust	82.95(13.54)	71.90(17.04)	13.97	374	**<.001**	0.72
	Fear	61.95(18.69)	76.20(15.08)	−17.46	374	<.001	0.84
	Happiness	88.95(11.93)	73.19(16.18)	21.04	374	**<.001**	1.11
	Sadness	75.64(16.42)	67.40(17.08)	10.72	374	**<.001**	0.49
	Surprise	80.98(13.53)	78.28(14.53)	4.45	374	**<.001**	0.19
Intensity	Anger	56.29(19.92)	56.27(18.21)	0.03	374	< .980	<0.01
	Disgust	71.36(19.22)	63.07(18.28)	9.69	374	**<.001**	0.44
	Fear	50.47(19.32)	67.56(19.11)	−18.98	374	<.001	0.89
	Happiness	63.66(24.84)	44.35(23.02)	18.49	374	**<.001**	0.81
	Sadness	61.03(21.10)	53.74(19.41)	7.97	374	**<.001**	0.36
	Surprise	58.42(21.56)	62.66(19.56)	−5.26	374	<.001	0.21
Genuineness	Anger	49.02(23.01)	55.15(20.52)	−6.53	374	<.001	0.28
	Disgust	56.20(25.73)	53.70(21.82)	2.37	374	.018	0.10
	Fear	47.07(20.20)	61.57(21.48)	−15.33	374	<.001	0.70
	Happiness	76.15(18.73)	64.99(20.33)	11.28	374	**<.001**	0.57
	Sadness	47.50(24.03)	60.21(20.47)	−10.19	374	<.001	0.57
	Surprise	49.66(24.26)	57.76(20.53)	−9.32	374	<.001	0.36

The bold font indicates greater recognition, confidence, intensity, or genuineness ratings for emotion faces with sunglasses compared to masks, while the underlined font represents higher recognition, confidence, intensity, or genuineness ratings for emotion faces with masks compared to sunglasses. An effect was deemed significant only when the *p*-value fell below the threshold of 0.008 (=0.05/6 comparisons).

also significant. For disgust, happiness, and sadness, participants rated faces with sunglasses as more intense compared to faces with masks. However, for fear and surprise, participants rated faces with masks as more intense than sunglasses. There was no significant effect of Face Covering on intensity ratings for anger.

Furthermore, the three-way Face Covering, Emotion, by Time interaction was also significant. Consistent with previous analyses, we disaggregated this interaction by examining each emotion separately. The Face Covering by Time interaction was only significant for expressions of disgust, $F(3, 371) = 3.96$, $p = 0.008$, $\eta_p^2 = 0.03$, and happiness, $F(3, 371) = 9.76$, $p < 0.001$, $\eta_p^2 = 0.07$. Because our primary interested was whether the impact of specific types of face coverings on emotional perception varied over time, we further examined each face covering separately, see Fig. 2. For faces with sunglasses expressing disgust, the intensity ratings varied over time, $F(3, 371) = 4.45$, $p = 0.004$, $\eta_p^2 = 0.03$. Specifically, expressions of disgust were rated as more intense at T4 ($M = 75.11$, $SD = 18.65$) and T3 ($M = 73.79$, $SD = 19.31$) than at T1 ($M = 65.85$, $SD = 18.08$), $t(187) = 3.46$, $p < 0.001$, Cohen's $d = 0.50$, and $t(179) = 2.85$, $p = 0.005$, Cohen's $d = 0.42$, respectively. No other differences were significant, $ps \geq 0.069$ (with a Bonferroni-corrected alpha level at $0.008 = 0.05/6$ comparisons). In contrast, intensity ratings for faces with masks expressing disgust did not vary over time, $F(3, 371) = 0.44$, $p = 0.725$, $\eta_p^2 < 0.01$. For faces with sunglasses expressing happiness, the intensity ratings varied over time, $F(3, 371) = 3.70$, $p = 0.012$, $\eta_p^2 = 0.03$. In particular, expressions of happiness were rated as more intense at T3 ($M = 67.31$, $SD = 24.45$) than at T1($M = 56.17$, $SD = 25.70$), $t(179) = 2.99$, $p = 0.003$, Cohen's $d = 0.44$. No other differences were significant, $ps \geq 0.012$ (with a Bonferroni-corrected alpha level at 0.008). Intensity ratings for faces with masks expressing happiness, however, did not vary over time, $F(3, 371) = 1.71$, $p = 0.164$, $\eta_p^2 = 0.01$.

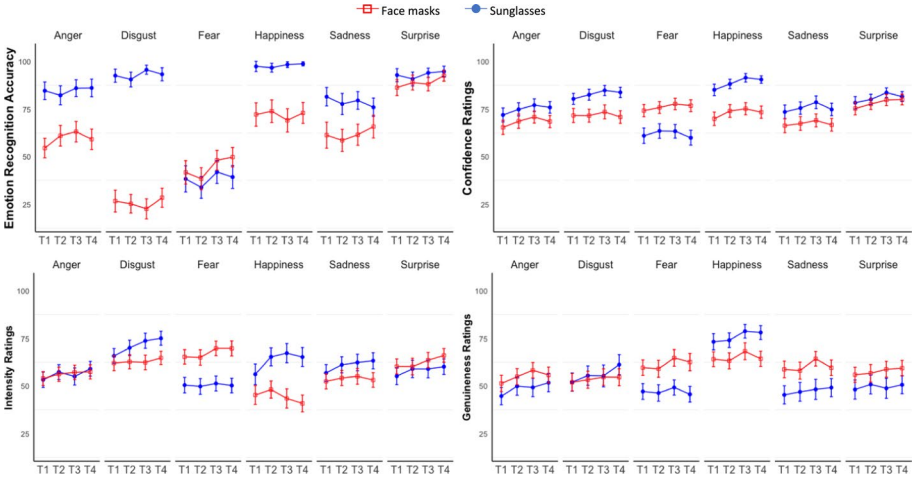

Fig. 2 Emotion recognition accuracy, confidence, intensity, and genuineness ratings for faces with masks versus sunglasses across four time points. *Note*: T1 = June 14–June 23, 2020; T2 = March 4–March 23, 2021; T3 = September 12–September 25, 2021; T4 = June 24–July 8, 2022

Perceived Emotion Genuineness

For genuineness ratings, the main effects of Face Covering and Emotion were both significant. These effects, however, were again qualified by the two-way Face Covering by Emotion interaction. The three-way Face Covering, Emotion, by Time interaction was not significant. Simple effects analyses demonstrated that participants rated faces with masks compared to sunglasses as more genuine for expressions of anger, fear, sadness, and surprise. Notably, faces with sunglasses compared to masks were perceived as more genuine for happy expressions. The effect of Face Covering on genuineness rating for expressions of disgust was not significant.

Taken together, these findings suggest that, apart from the sporadic effects of sunglasses on perceived intensity of disgust and happiness over time, the overall impact of face coverings, both masks and sunglasses, on emotion recognition accuracy, confidence, perceived intensity, and genuineness remained relatively stable over two years.

Comparing Faces with and without Masks and Sunglasses at T4

To investigate whether differences in emotion perceptions between faces with masks and sunglasses were due to the occlusion of the eye or mouth area, we first calculated the difference between faces with masks and without covering, as well as the difference between faces with sunglasses and without covering. We then compared these two difference scores with 0 for each emotion. Significant positive differences from 0 would indicate that faces with covering (i.e., masks or sunglasses) elicited higher ratings compared to uncovered faces, while significant negative differences would suggest that covered faces received lower ratings. The means, standard deviations, and one-sample *t*-test results comparing the impact of the specific face covering (i.e., masks or sunglasses) for each emotion against 0 can be found in Supplementary Table S1. Figure 3 presents difference scores of each face covering for all six emotions.

Emotion Recognition Accuracy

Overall, the reduction in emotion recognition accuracy was significantly greater for faces with masks ($M = 28.75$, $SD = 32.77$) compared to faces with sunglasses ($M = 8.83$, $SD = 25.88$), $t(605) = 13.12$, $p < 0.001$, Cohen's $d = 0.53$, 95% CI = [0.448, 0.618]. In particular, sunglasses were observed to impair the recognition of fear and sadness expressions. However, no significant impairment was observed for expressions of disgust, happiness, or surprise. Notably, the recognition of anger was facilitated in faces with sunglasses compared to faces without covering. Conversely, masks uniformly decreased the recognition accuracy for all emotional expressions, with the exception of surprise.

Confidence Ratings

The reduction in confidence ratings was significantly greater for faces with masks ($M = 11.97$, $SD = 15.57$) compared to faces with sunglasses ($M = 6.91$, $SD = 13.87$), $t(605) = 6.76$, $p < 0.001$, Cohen's $d = 0.27$, 95% CI = [0.193, 0.356]. The confidence ratings of faces with sunglasses compared to faces without covering was reduced for all

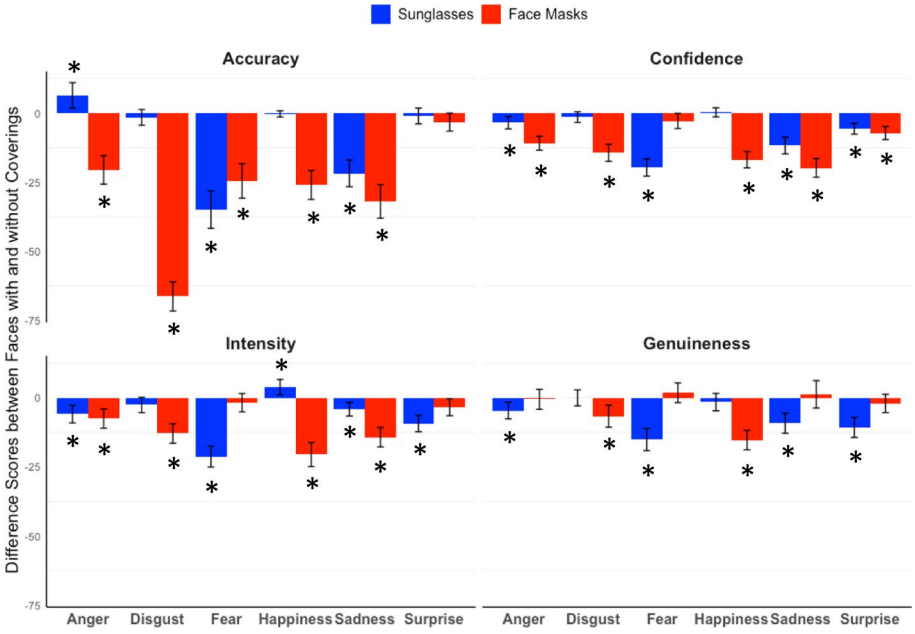

Fig. 3 Difference scores in emotion recognition accuracy, confidence, intensity, and genuineness ratings between faces with and without masks/sunglasses at T4. *Note*: Bars marked with asterisks indicate significant differences from 0. Error bars represent 95% confidence intervals

emotions, except for disgust and happiness. Similarly, confidence ratings of all faces with masks compared to faces without covering was reduced for all emotions, except for fear.

Perceived Emotion Intensity

Overall, the reduction in perceived emotion intensity was significantly greater for faces with masks ($M = 10.08$, $SD = 19.15$) compared to faces with sunglasses ($M = 6.57$, $SD = 17.13$), $t(605) = 4.04$, $p < 0.001$, Cohen's $d = 0.16$, 95% CI = [0.084, 0.244]. The perceived intensity of faces with sunglasses compared to faces without covering was reduced for all emotions, except for disgust and happiness. Surprisingly, happy expressions were rated as less intense on uncovered faces compared to faces with sunglasses. Additionally, the perceived intensity of faces with masks compared to faces without covering was reduced for all emotions, except for fear and surprise.

Perceived Emotion Genuineness

In contrast to the above measures, the reduction in perceived emotion genuineness was significantly greater for faces with sunglasses ($M = 6.89$, $SD = 17.95$) compared to faces with masks ($M = 3.59$, $SD = 20.37$), $t(605) = 3.86$, $p < 0.001$, Cohen's $d = 0.16$, 95% CI = [0.077, 0.237]. Furthermore, the perceived genuineness of faces with sunglasses compared to faces without covering was reduced for anger, fear, sadness, and surprise. Conversely, the

genuineness of faces with masks compared to faces without covering was reduced for disgust and happiness.

Overall, the results suggest that both types of facial coverings (masks and sunglasses), to some extent, impair emotion recognition, confidence, intensity, and genuineness judgments of facial expressions. However, exceptions to this trend (e.g., sunglasses increasing the recognition accuracy of angry faces and the perceived intensity of happy faces) highlight the complex effects that facial coverings have on the perception of emotions.

Discussion

The primary goal of the current research was to investigate the influence of masks and sunglasses on the perception of facial expressions and to explore changes in these effects during the COVID-19 pandemic. Our findings, based on data collected across four waves, demonstrated that participants were generally less accurate and less confident in recognizing emotions on faces with masks than sunglasses. Moreover, the intensity of emotions on faces with masks compared to sunglasses was perceived as significantly muted. However, faces with masks compared to sunglasses were rated as more genuine in conveying emotional expressions.

The impact of masks and sunglasses on the perception of facial expressions was further nuanced by the specific emotions being expressed. For all basic emotions, with the exception of fear, participants showed less accuracy and confidence in their judgments of faces with masks compared to sunglasses. In contrast, when assessing fear, participants were less accurate and confident when judging faces with sunglasses compared to masks. Furthermore, participants rated disgusted, happy, and sad faces with sunglasses compared to masks as more intense. However, participants rated fearful and surprised faces with masks compared to sunglasses as more intense. No significant difference was found for the perceived intensity of anger. Finally, participants rated angry, fearful, and sad faces with masks compared to sunglasses as more genuine, while they rated happy faces with sunglasses compared to masks as more genuine. Notably, there was no significant difference between masks and sunglasses on the perceived genuineness of disgust.

Comparing Perception of Faces with and without Masks/Sunglasses

Although these findings diverge from the results of Noyes et al. (2021), they align with the findings of Kim et al. (2022) that indicate that recognition accuracy of facial expressions is significantly compromised for faces with masks compared to sunglasses for all basic emotions except fear. It is important to note that this similar pattern of results was found in two distinct cultures—Korea and Canada, where divergences in familiarity and the social connotations of masks and sunglasses exist. Specifically, whereas the use of masks in public is common in Korea since the 2003 SARS outbreak, face masks has only become widespread in Canada since the start of the COVID-19 pandemic in 2020. Moreover, the social significance attached to masks may differ across cultures, with East Asians compared to Westerners wearing masks for a broader range of reasons (e.g., avoiding makeup or social isolation), thereby potentially weakening the association between masks and health issues (Jennings, 2020; Joung, 2020). Canadians, however, may be more familiar with sunglasses compared to Koreans and other East Asians (Kim et al., 2022). Despite these cultural differences, it is compelling that in the study by Kim et al. (2022) with Korean participants

and in our study with Canadian participants, the impact of masks and sunglasses on facial expression perception was similar. This finding suggests that these effects may primarily stem from the occlusion of facial features, rather than the social meaning associated with masks or sunglasses.

This possibility is corroborated by a study where participants viewed films featuring female subjects with either fully visible faces, faces covered by a niqab, or faces partially visible with the lower part obscured by a black bar (Fischer et al., 2012). The results showed that covering the lower part of the face (i.e., the niqab and partial face conditions) led to the perception of less happiness in happy videos and more intense negative emotions in both happy and shame videos, compared to the fully visible face condition. Importantly, there were only marginal differences between the niqab and the partial-face conditions, depending on the specific videos and rating scales employed, suggesting that emotion identification is determined primarily by the presence or absence of expressive cues.

The Role of Expressive Cues in Emotion Perception

Our research further elucidates the differential role of the eye and mouth regions in communicating emotions by comparing the perception of faces with coverings (masks or sunglasses) and without coverings. Overall, the reduction in emotion recognition accuracy was approximately 29% for faces with masks, which is somewhat larger than the 23% reported by Grahlow et al. (2022), the 20% reported by Rinck et al. (2022), the 19% reported by Noyes et al. (2021), and the 17% reported by Carbon (2020). The reduction in emotion recognition accuracy for faces with sunglasses was approximately 9%, which is also somewhat larger than the 4% reported by both Kim et al. (2022) and Noyes et al. (2021). Together, these results consistently indicate that occluding either the mouth or eye region impairs emotion recognition, and that the mouth region plays a more important role in the communication of emotional categories. Regarding the role of expressive cues in the recognition of specific emotions, we found that occluding the mouth region decreased the recognition of almost all basic emotions (except surprise), while occluding the eye region significantly reduced the recognition of fear and sadness.

Regarding the perceived intensity of emotions, we observed that the reduction was around 10% for masks and 7% for sunglasses. This finding indicates that occluding the mouth or eye region diminishes the perceived emotional intensity, with the mouth region being more important for conveying emotional intensity. Specifically, occluding the mouth region significantly reduced the perceived intensity of all basic emotions (except fear and surprise), while occluding the eye region significantly reduced the perceived intensity of all basic emotions (except disgust and happiness).

In contrast, we found that the reduction in perceived emotional genuineness was around 4% for masks and 7% for sunglasses. This finding suggests that occluding the eye or mouth region diminishes the perceived genuineness of emotions, with the eye region being more important for conveying genuineness. Occluding the eye region significantly reduced the perceived genuineness of all basic emotions (except disgust and happiness), while occluding the mouth region only reduced the perceived genuineness of disgust and happiness. This finding aligns with previous research suggesting that because voluntary control of muscles in the eye area is more challenging than in the mouth area (Ekman et al., 2002), genuine emotions are more likely to be expressed through the upper half of the face (Porter et al., 2012). Participants in our study, therefore, may have relied more on signals from the eye area to assess the genuineness of emotions.

It is worth noting that the present results indicated that happy faces with sunglasses were perceived as more genuine than those with masks. This finding may initially appear to conflict with prior research emphasizing the importance of the Duchenne marker (i.e., AU6, cheek raiser) in the perception of genuine happiness (Ekman & Friesen, 1982). Specifically, past research has consistently demonstrated that smiles involving both the AU6 and the AU12 (mouth corner raised) are perceived as more genuine than those with only the AU12 (Del Giudice & Colle, 2007; Gosselin et al., 2002; Krumhuber & Manstead, 2009). In the current research, however, we found that happy faces displaying the AU12 but lacking the Duchenne marker (i.e., happy faces with sunglasses) were perceived as more genuine than those with the Duchenne marker but lacking the AU12 (i.e., happy faces with masks). We speculate this may be because smiles with sunglasses were perceived as more intense than those with masks. Given that smile intensity is also an important indicator of smile genuineness (Gunnery & Ruben, 2016; Gunnery et al., 2013; Mai et al., 2011; Thibault et al., 2012), the higher intensity of smiles with sunglasses may have contributed to their perceived greater genuineness compared to smiles with masks.

Perception of Faces with Masks and Sunglasses Across Time

Contrary to our initial assumption, we observed a consistent effect of both masks and sunglasses on perceptions of emotions over the two-year period from June 2020 to June 2022. In accordance with a recent study by Freud et al. (2022) that demonstrated persistent deficits in recognition of masked faces at six different time points between May 2020 and January 2022, our results also did not show any signs of improvement over time. Notably, Freud et al. (2022) also found that participants' experience with masks was not related to the effects of masks on identity recognition. One possible explanation for these findings is that the face processing system develops rapidly in infancy, and by adulthood, the mechanisms for facial recognition have already been established and therefore are less likely to be influenced by experience (Pascalis et al., 2020; Yovel et al., 2012). Similarly, previous studies have found that children's ability to recognize facial expressions significantly improves between the ages of five and nine, but there is no difference in facial expression recognition between 11-year-old children and adults (Durand et al., 2007). These findings suggest that children may develop full emotion perception capabilities before the age of 11, at which point this ability stabilizes. Although Canadian individuals in the current study have only recently been exposed to mask-wearing environments more regularly, this experience may not be sufficient to change how they process facial expressions. However, we recommend further research to monitor whether and how masks impact emotion perception over time and across cultures with a focus on measured exposure to masked faces.

Limitations, Constraints on Generality, and Future Directions

It is important to note that one limitation of the current study is that we did not track the same group of participants over time. Although it is possible that a within-subjects factorial design may be more sensitive to the impact of time on emotion perceptions of faces with masks and sunglasses, we doubt the current pattern of results would have fundamentally changed. Even though we recruited four different groups of participants at four different time points, their ratings of recognition, confidence, intensity, and genuineness of the six emotions were remarkably similar over this period and would be expected to be even more so if the same groups of participants were used across waves. Although further research is

advisable, our findings provide novel evidence that people's ability to judge emotions on faces with masks and sunglasses may be relatively stable.

One potential constraint on the generality of the results is our exclusive recruitment of university students as participants. Although previous research has shown that factors such as age, education, and ethnicity can influence the absolute accuracy of emotion recognition (Dodell-Feder et al., 2020; Fang et al., 2022; Friesen et al., 2019; Kawakami et al., 2022), we have no reason to believe that employing diverse groups would alter the relative effects of sunglasses and masks on emotion perception. However, for younger children whose emotion recognition abilities are still developing (Durand et al., 2007), the impact of masks may vary as they gain more experience with masked faces. Future researchers could consider using an exposure paradigm (Kawakami et al., 2017) to investigate whether extensive experience with masked expressions affects emotion recognition.

Another potential constraint is our facial stimuli. In this study, we utilized FACS-based prototypes of emotional expressions with masks and sunglasses digitally superimposed on Caucasian models. While the impact of facial occlusion may be more pronounced for lower-intensity expressions, which are more ambiguous, the present results demonstrated consistent and robust effects of masks and sunglasses on emotion identification, even for high-intensity expressions. Furthermore, although the superimposed masks and sunglasses maintained consistency across conditions, the stimuli may appear more artificial than real-world masked or sunglass-wearing faces. However, prior research has shown that images with superimposed masks impair emotion recognition in a similar manner to images with actual mask-wearing faces (Grenville & Dwyer, 2022).

Future research could explore the impact of masks and sunglasses on the recognition of a wider range of emotional expressions, beyond the six basic emotions, and using more naturalistic and dynamic facial stimuli. Although Kastendieck et al. (2021) found that masks did not reduce the recognition rate of dynamic happy and sad expressions, this may be partly attributed to the simplified experimental task involving only two emotions. It is possible that dynamic information could compensate for the negative impact of masks on expression recognition, given prior evidence of better recognition for dynamic versus static expressions, particularly when certain facial information is limited or absent (Fiorentini & Viviani, 2011; Krumhuber et al., 2013, 2023).

Another important avenue for future research is to examine perceptions of non-White faces with and without occlusion, and the role of ingroup bias and stereotypes in this process. For instance, would decreasing the visibility of emotional expressions via facial coverings heighten the effect of stereotypical associations between social groups and emotions, such that masked Black faces would be perceived more negatively compared to unmasked Black faces due to stereotypes linking this group with anger and hostility (Karmali & Kawakami, 2023; Kawakami et al., 2017, 2020)? Although a recent study by Primbs et al. (2022) did not find that masks increased reliance on the Moroccan-anger stereotype, further exploration of this issue with a variety of racial target and perceiver groups is warranted (Kawakami et al., 2024).

Conclusion

Overall, the present study suggests that face masks impair the recognition of many emotions and confidence in these judgments, as well as the perceived intensity of emotions to a greater extent than sunglasses. Our findings, however, also indicated that sunglasses impair

emotion genuineness to a greater extent than face masks. Importantly, the impact of both masks and sunglasses on perceivers' ability to judge the emotions of faces was relatively stable over a two-year period during the COVID-19 pandemic.

As we now find ourselves in a post-pandemic era, with the withdrawal of mask mandates and a relative subsidence of the COVID-19 pandemic, the notions of stigma and social acceptability associated with mask-wearing may adjust accordingly. This changing social context serves as a contrasting backdrop that can further inform the interpretation of our study results and presents a unique opportunity for follow-up research. The psychological residue of mask-wearing and its impact on communication may persist or evolve in unforeseen ways, providing fertile ground for future investigations as well as inform our response to future pandemics.

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Author Contributions X. Fang and K. Kawakami developed the study concept and design. X. Fang collected data, performed the data analysis and interpretation. X. Fang drafted the manuscript, and K. Kawakami provided critical revisions. Both authors approved the final version of the manuscript for submission.

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Declarations

Conflict of interest The authors declare no competing interests.

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