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Journal
Proceedings of the Annual Meeting of the Cognitive Science Society, 44(44)

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Publication Date
2022

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Abstract

Here we examined whether one's perceptual style in viewing own- and other-race faces is associated with performance and bias in social categorization by race, and whether mask use modulates the perceptual style and social categorization effects. We found that Asian participants who adopted more eyes-focused eye movement patterns when viewing Asian faces had a larger bias to judge 50% Asian-Caucasian face morphs as Asian. However, although mask use made participants' viewing pattern more eyes-focused, it did not change this bias in judging morphed faces, or other-race advantage in social categorization speed. These results suggest that information from the eye region may be sufficient to induce these social categorization effects, and that transient perceptual input change due to mask use does not modulate these social categorization effects. Thus, effects and biases in social categorization may be impervious to mask use. These findings have important implications for social interaction during the pandemic.

Keywords: eye movements; EMHMM; face processing; mask; social categorization

Introduction

During the COVID-19 pandemic, mask wearing has become a regular practice across the world, especially in Asian countries. As adults have developed expertise in extracting essential information from holistic perception of a face through years of experience (Richler et al., 2011; Tsao & Livingstone, 2008), having the lower half of the face covered by a mask may significantly affect how we view and process faces. Recent research has shown that mask use impairs face categorization accuracy and speed on various dimensions, including emotion, gender, age, and identity (Fitousi et al., 2021; Freud et al., 2020; Gulbetekin, 2021). Also, people shift their focus to the eye region when viewing faces with a mask, with a higher daily masked-face exposure associated with a larger attention shift (Barrick, Thornton & Tamir, 2021). Furthermore, in face recognition, individuals who adjust their eye movement strategies to focus more on the eye region due to mask use during face learning have less impairment in recognition performance (Hsiao, Liao & Tso, 2022). Nevertheless, it remains unclear how mask use influences our perception of other-race faces, an important issue in the age of globalization with increasing cross-racial interactions. Here we aim to fill this research gap by examining how mask use influences our performance and bias in social categorization by race as well as perceptual styles for own- vs. other-race faces as reflected in eye movement pattern.

In face recognition, an other-race effect has been consistently reported where better performance was observed in the recognition of own-race than other-race faces (Meissner, & Brigham, 2001 for review). In contrast, in social categorization by race, people categorize other-race faces more rapidly than own-race faces with no difference in accuracy. Interesting, slower speed in categorizing own-race faces is associated with faster response in face recognition, suggesting that our expertise in individualizing own-race faces during recognition can interfere with social categorization by race (Ge et al., 2009). Nevertheless, it remains unclear how mask use may affect this other-race advantage in social categorization.

Morphed faces, a combination of two different faces, were adopted in recent studies to investigate perceptual bias in social categorization by race (Lewis, 2016; Young et al., 2021). Previous research reported that 50% morphs were judged with a higher resemblance with their atypical than typical parent, suggesting that more distinctive or unusual faces based on one's face space were more salient in the perception of morphed faces (Tanaka et al., 1998). Consistent with this finding, other studies found that morphed faces were more likely to be categorized as other-race than own-race faces (e.g., Lewis, 2016; Halberstadt, Sherman & Sherman, 2011; Benton & Skinner, 2015). However, it was also found that people from various cultural backgrounds are generally

In J. Culbertson, A. Perfors, H. Rabagliati & V. Ramenzoni (Eds.), *Proceedings of the 44th Annual Conference of the Cognitive Science Society*.

more likely to categorize 50% Asian-Caucasian morphed faces as Asian than Caucasian (Chen & Hamilton, 2012), suggesting the possibility of higher Asian resemblance in 50% Asian-Caucasian morphs. Thus, it remains inconclusive how Asians categorize these ambiguous faces and how mask use affects the bias.

In the perceptual style of viewing own- vs. other-race faces, previous studies have reported a higher frequency of looking at the eye region for other-race faces and a higher frequency of looking at the nose region for own-race faces. For example, Hu et al. (2014) reported that both Chinese children and adults made a larger proportion of fixations on the eye region of Caucasian faces than Asian faces and a larger proportion of fixations on the nose region of Asian faces than Caucasian faces during passive viewing. Similarly, Liu et al. (2011) found that Chinese infants had decreased attention to Caucasian noses and unchanged attention to Chinese noses with increasing age during passive viewing of faces for later recognition. Adopting the same task, Xiao et al. (2014) found that Caucasian infants also show unchanged attention to Caucasian noses and decreased attention to Chinese noses with increasing age. However, it remains unclear whether these preferred perceptual styles in viewing own- and other-race faces are related to our performance and biases in social categorization by race, and how mask use affects these perceptual styles.

To fill these research gaps, here we aimed to investigate whether individual difference in perceptual style when viewing own- and other-race faces is associated with performance and bias in social categorization by race, and whether mask use influences our performance and biases in social categorization and perceptual style in viewing own- and other-race faces. We recruited Asian participants to perform social categorization by race and passive face viewing for measuring perceptual styles through eye tracking. To quantitatively assess participants' perceptual style as reflected in eye movement pattern (e.g., Hsiao, Lan, et al., 2021; Chan, Barry et al., 2020; Chan, Suen et al., 2020, 2021; Zheng et al., 2022), we adopted a machine-learning-based method, Eye Movement analysis with Hidden Markov Models (EMHMM; Chuk et al., 2014), which takes both the spatial and temporal dimensions of eye movements into account. This approach enables us to examine eye movements more comprehensively than traditional descriptive measures such as fixation counts (Wu et al., 2012; Goldinger et al., 2009). We hypothesized that individual differences in perceptual style when viewing own- and other-race faces may be associated with performance and bias in social categorization by race, and mask use may reduce these performance difference, bias and difference in perceptual style by directing people's attention to the eye region of both Asian and Caucasian faces.

Method

Participants

55 Chinese participants (41 females) between 17 to 30 years old (M = 19.91; SD = 2.86) were recruited from a local university in Hong Kong[1]. They had normal or corrected-to-normal vision with no self-reported cognitive disabilities or psychological problems. Participants' own-race contact (M = 5.08, SD = 0.72) was significantly higher than other-race contact (M = 3.56, SD = 0.70), $t(54) = -12.46$, $p < .001$, $d = -1.68$, based on self-reported Racial Contact Questionnaire (Hancock & Rhodes, 2008).

Materials and Apparatus

The materials used in the social categorization task consisted of face images from 16 individuals (8 Asians and 8 Caucasians) adapted from Sheng and Han (2012). Each individual had an unmasked and a masked face image.

The materials used in the social categorization bias task consisted of 8 morphed faces with an artificial combination of 50% of Asian and Caucasian faces respectively. The original unmorphed faces were adapted from Sheng and Han (2012). Each face image had an unmasked and a masked version. FunMorph software (http://www.funmorph.com/) was used to generate morphed faces.

The materials used in the passive viewing (PV) task contained face images from 16 individuals (8 Asians and 8 Caucasians), among which Caucasian faces were from the FACES database (Ebner, Riediger, & Lindenberger, 2010) and Asian faces were adapted from Zhang et al. (2019). Each individual had a neutral and a happy face and each face image had an unmasked and a masked version. Examples of Asian and Caucasian faces under masked and unmasked conditions were shown in Figure 1.

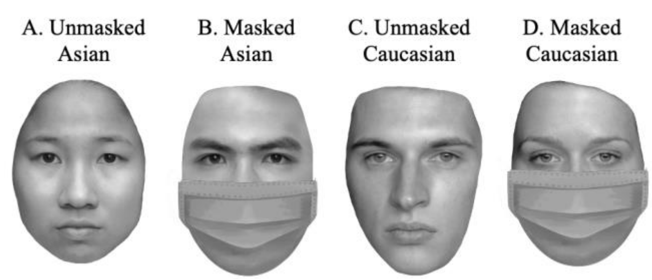


Figure 1: Example Asian and Caucasian faces with and without masks in the passive viewing task.

All face stimuli were aligned at the center point between the two eyes and were grey-scaled and then normalized in luminance and spatial frequency distribution (histMatch)

[1] Out of 55 participants, 7 participants didn't complete the social categorization task due to technical problems, resulting in 48 completed data. A power analysis of 2 x 2 repeated measures ANOVA assuming a medium effect size ($f = .15$, power = .80, $\alpha = .05$) using MorePower (Campbell & Thompson, 2012) showed that the required sample size was 48. A power analysis of paired t-test assuming a medium effect size ($d = 0.5$, power = .80, $\alpha = .05$) showed that the required sample size was 34.

using SHINE Toolbox (Willenbockel et al., 2010). A surgical face mask with luminance and spatial frequency distribution matched to the lower half of the corresponding face was added using Adobe Photoshop software to create masked faces. The width of the faces on the screen was about 8° of visual angle (following Hsiao & Cottrell, 2008) from a 60cm viewing distance, resembling the size of a real face seen under a normal conversational distance 100 cm. EyeLink Portable Duo (SR Research) with a 1000 Hz sampling rate was used to record eye movements. A 510 mm x 290 mm monitor with a resolution of 1920 x 1080 pixels and a keyboard were used to collect behavioral responses. The social categorization task and the social categorization bias task were programmed using PsychoPy (Peirce et al., 2019), and the passive viewing task was coded in MATLAB with PsychoToolbox (Kleiner et al., 2007).

Design and Procedure

Participants performed three experimental tasks: the social categorization bias task, the social categorization task, and the passive viewing task. They then completed the Racial Contact Questionnaire and demographic questionnaire.

Social Categorization Task Participants were asked to judge whether the presented face was an Asian or a Caucasian face. There were in total 32 trials. Each trial started with a 300 ms blank screen, followed by a 500 ms fixation cross. The face stimulus then appeared at the screen center for 1500 ms. Participants pressed button "A" when they saw an Asian face and button "L" when they saw a Caucasian face.

A 2 (mask conditions: unmasked vs masked) by 2 (race: Asian vs Caucasian) repeated-measures ANOVA on the accuracy and RT was conducted to examine the effect of mask use and race on social categorization performance.

Social Categorization Bias Task Participants were asked to judge whether the presented morphed face was Asian or Caucasian. There were in total 16 trials. Each trial started with a 300 ms blank screen, followed by a 500 ms fixation cross. The face then appeared at the screen center for 1500 ms. Participants pressed button "A" when they thought the face was Asian and button "L" for Caucasian.

The percentage of own-race (Asian) responses was used to measure own-race categorization bias. Paired t-test comparing masked and unmasked conditions was performed to examine whether mask use influences people's own-race categorization bias.

Passive Viewing Task Participants were asked to view faces sequentially and pressed a key when they saw two consecutive same faces, with their eye movements recorded. It consisted of three sessions, with each containing two blocks. In each block, there were 144 trials, including 128 non-target trials and 16 target trials. The non-target trials consisted of 4 repetitions of 32 face images, with two images (with neutral and happy expressions respectively) from each of the 16 individuals., The target trials consisted of a face image of each of the 16 individuals. Each individual's faces were presented in either the masked or unmasked condition, and the mask condition of each individual was counterbalanced among participants. Only eye movements from non-target trials were analyzed. The purpose of the one-back design was to ensure that participants processed face identity information during passive viewing.

Each trial started with a solid circle at the screen center for drift correction, followed by a blank screen lasting for a randomized duration between 800 and 1200 ms. An 800 ms fixation cross then appeared. Participants were asked to look at the fixation cross when it appeared. Then a face image was presented for 1000 ms.

EMHMM (Chuk, Chan, & Hsiao, 2014) was used to analyze eye movement data. A participant's eye movements in each of the mask and race condition combinations were summarized using a hidden Markov model (HMM, a type of time-series statistical model in machine learning) in terms of personalized regions of interest (ROIs) and transition probability among ROIs. The number of hidden states was automatically determined using the variational Bayesian approach (McGrory & Titterington, 2009). The resulting 220 (4 models x 55 participants) individual models were then clustered to discover two representative patterns, pattern A and B, using the variational hierarchical expectation maximization (VHEM) algorithm (Coviello, Chan & Lanckriet, 2014). Following previous studies (Chuk et al., 2017; Chan et al., 2018; Zheng & Hsiao, 2020; Zhang et al., 2019; Chan, Barry, et al., 2020; Chan, Suen, et al., 2020; Chuk et al., 2020; An & Hsiao, 2021; Chan et al., 2021; Hsiao, An, et al., 2021; Hsiao, Lan, et al., 2021; Hsiao, Chan, et al., 2021; Lee et al., 2021; Zheng et al., 2022; Chan et al, 2022), we quantified each participant's eye movement pattern in a condition using A-B scale:

$$\text{A-B scale} = \frac{\text{A - B}}{|\text{A}| + |\text{B}|}$$

Where A is the log-likelihood of the participant's data being generated by the group A HMM, and B is the log-likelihood of the participant's eye movement data being generated by the group B HMM. The log-likelihood measure reflects the similarity of the participant's eye movement to the representative pattern. A more positive A-B scale indicates higher similarity to pattern A, whereas a more negative value indicates a higher similarity to pattern B.

A 2 (mask conditions: unmasked vs masked) by 2 (race: Asian vs Caucasian) repeated-measures ANOVA on A-B scale was conducted to examine the effect of mask use on perceptual style in processing own- and other-race faces. Correlation analysis between eye movement pattern in passive viewing as measured by A-B scale and the performance and bias in social categorization was conducted to examine whether perceptual style could account for the other-race effects in social categorization.

Results

The Effect of Mask Use on the Social Categorization Performance

In accuracy of the social categorization task, there was no main effect of race, $F(1,47) = 2.43$, $p = .126$, or mask condition, $F(1,47) = 0.91$, $p = .345$. There was a marginal interaction between mask condition and race, $F(1,47) = 3.78$, $p = .058$, $\eta^2 = 0.016$ (Figure 2A): Participants had higher categorization accuracy for Asian faces than Caucasian faces under masked conditions, $t(47) = 2.54$, $p = .015$, but not under unmasked condition, $t(47) < 0.01$, $p = 1.000$. This result suggested that mask use made other-race faces more difficult to categorize as compared with own-race faces.

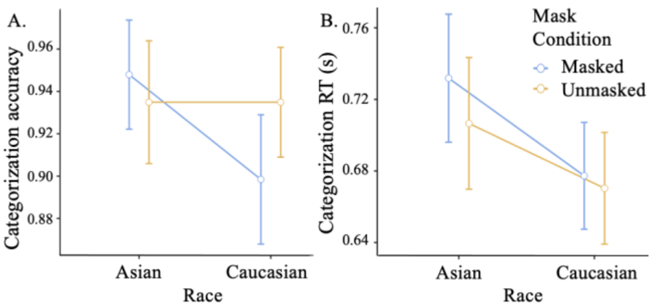


Figure 2: The effect of mask condition and race on (A) accuracy and (B) RT in the social categorization task.

For RT, there was a main effect of race, $F(1,47) = 12.64$, $p < 0.001$, $\eta^2 = 0.038$. Participants responded slower in categorizing Asian faces than Caucasian faces, consistent with the other-race advantage effect in social categorization observed in the literature. The main effect of mask was marginal, $F(1,47) = 3.56$, $p = .065$, $\eta^2 = 0.005$, and no interaction effect was found, $F(1,47) = 0.931$, $p = .339$ (Figure 2B). This result suggested that the other-race categorization advantage in RT was unaffected by mask use.

The Effect of Mask Use on the Social Categorization Bias

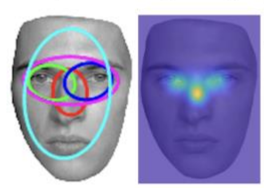
Based on one-sample t-test against 50%, morphed faces were significantly more likely to be categorized as Asian/own-race faces under both the masked ($M = 64.3\%$, $SD = 0.23$), $t(47) = 4.25$, $p < .001$, $d = 0.61$, and unmasked conditions ($M = 63.3\%$, $SD = 0.24$), $t(47) = 3.77$, $p < .001$, $d = 0.55$; this categorization bias effect did not differ between the masked and unmasked condition, $t(47) = -0.34$, $p = 737$, $d = -0.05$. This result indicated that mask use did not modulate this social categorization bias.

In an explorative analysis, we found that larger own-race bias for masked morphed faces was correlated with lower categorization accuracy for masked Caucasian faces, $r(46) = -.36$, $p = .013$. This result suggested that people who were poorer in categorizing masked Caucasian faces were more likely to judge 50% morphed faces as Asian/own-race faces.

Eye Movement Pattern during Passive Viewing

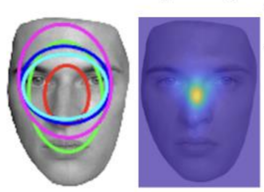
In passive viewing[2], we discovered two representative eye movement patterns as the result of clustering: the eyes-focused and nose-focused patterns (Figure 3). This finding was consistent with previous EMHMM studies on face recognition (Chuk et al., 2014; Chuk, Crookes, et al., 2017; Chuk, Chan et al., 2017; Chan et al., 2018; An & Hsiao, 2021; Hsiao, An, et al., 2021). After the first fixation at the face center/red ROI due to drift correction (94% probability), participants adopting the eyes-focused pattern typically started to fixate on the eye region including left eye/green ROI (50%), right eye/blue ROI (26%), and the pink ROI covering the whole eye region (22%). After looking at the left eye/green ROI, they had a 4% probability to stay at the green ROI, 68% probability to transit to the right eye/blue ROI, 19% probability to transit to the pink ROI, and 9% probability to look at other face regions covered by the broad cyan ROI. 107 models were assigned to this pattern group. In contrast, participants adopting the nose-focused pattern started at the center of face/red ROI (87%) and mainly look at the face center covered by broad ROIs. 113 models were assigned to this pattern group. The two representative HMMs differed significantly (Chuk et al., 2014): data from those with the eyes-focused pattern were more likely to be generated from the eyes-focused than nose-focused HMM, $t(106) = 24.41$, $p < .001$, $d = 2.32$, and data from those using the nose-focused pattern were more likely to be generated from the nose-focused than the eyes-focused HMM, $t(112) = 7.95$, $p < .001$, $d = 0.71$. To be consistent with previous studies, here we refer to A-B scale as Eyes-Nose scale.

A. Eyes-focused pattern (107 models)



Nose-focused	To Red	To Green	To Blue	To Pink	To Cyan
Priors	.94	.00	.00	.03	.02
From Red	.00	.50	.26	.22	.02
From Green	.00	.04	.68	.19	.09
From Blue	.00	.39	.02	.53	.07
From Pink	.00	.06	.05	.84	.05
From Cyan	.00	.02	.02	.28	.68

B. Nose-focused pattern (113 models)



Nose-focused	To Red	To Green	To Blue	To Pink	To Cyan
Priors	.87	.03	.00	.09	.00
From Red	.00	.47	.14	.01	.38
From Green	.00	.94	.03	.01	.02
From Blue	.00	.24	.37	.39	.01
From Pink	.00	.00	.00	1.0	.00
From Cyan	.00	.35	.43	.08	.13

Figure 3: The (A) eyes-focused and (B) nose-focused patterns. Ellipses show ROIs as 2-D Gaussian emissions.

[2] Participants had high accuracy ($M = 0.94$, $SD = 0.09$) in the passive viewing task with the one-back design, indicating that they maintained good attention on the task stimuli.

The table shows transition probabilities among the ROIs. Priors show the probabilities that a fixation sequence starts from the ellipse. The image in the middle shows the corresponding heatmap.

Does Perceptual Style in Viewing Own- and Other-Race Faces Predict Other-Race Effects in Social Categorization?

Here we tested whether perceptual style during passive viewing was associated with other-race advantage in social categorization RT and own-race categorization bias in the perception of regular, unmasked faces. According to Pearson's correlation analysis, participants with a more eyes-focused pattern in viewing unmasked Asian faces in PV was associated with a larger social categorization bias to categorize unmasked morphed faces as own-race faces, $r(46) = .32$, $p = .026$. In contrast, eye movement pattern during viewing unmasked Asian or Caucasian face was not associated with the other-race advantage in social categorization RT.

The Effect of Mask Use on Perceptual Style

In eyes-nose scale, there was a main effect of race, $F(1,54) = 16.78$, $p < 0.001$, $\eta^2 = 0.004$. Participants were more eyes-focused when viewing Caucasian faces than Asian faces. There was also a main effect of mask, $F(1,54) = 65.01$, $p < 0.001$, $\eta^2 = 0.136$. Participants had a more eyes-focused pattern when viewing masked faces than unmasked faces. These effects interacted with each other, $F(1,54) = 4.41$, $p = .040$, $\eta^2 = 0.001$ (Figure 4). The post-hoc Tukey's t-test showed that participants adopted a more eyes-focused pattern when viewing Caucasian faces than Asian faces under the unmasked condition, $t(54) = -4.32$, $p < 0.001$, while there was no difference between viewing Asian and Caucasian faces under the masked condition, $t(54) = -2.15$, $p = .152$. This result suggested that mask use reduced the other-race effect on eye movement pattern in face perception.

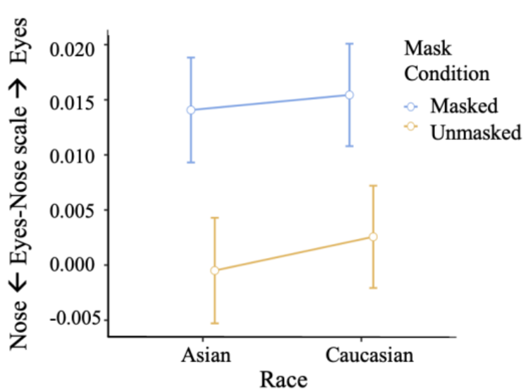


Figure 4: The interaction effect between mask condition and race in eyes-nose scale.

Discussion

In this study, we examined whether the difference in perceptual style when viewing own- and other-race faces, as reflected in eye movement pattern, was associated with the other-race advantage in social categorization RT and the bias in social categorization of ambiguous, 50% morphed faces, and whether mask use influences these social categorization effects and perceptual style in viewing own- and other-race faces. Through the data-driven machine-learning based approach, EMHMM, we discovered two representative eye movement patterns, eyes-focused and nose-focused patterns, in viewing faces. We found that participants who were more eyes-focused in viewing own-race faces were more likely to categorize ambiguous faces as their own race. This result suggested that the bias in ambiguous face categorization is associated with one's perceptual style for own-race faces. In contrast, eye movement pattern during own- or other-race face viewing was not associated with the other-race advantage in social categorization RT, suggesting different cognitive mechanisms involved.

In the literature on ambiguous face categorization, it has been argued that a more distinct and unusual face parent away from the center of face space may be perceived as more salient, leading to a bias to judge an ambiguous face as more similar to the more unusual face parent (Tanaka et al., 1998). This argument is consistent with some previous studies reporting that ambiguous faces were typically judged to resemble other-race faces more than own-race faces (Lewis, 2016; Benton & Skinner, 2015). However, this other-race bias effect may be race-specific, since for Asian-Caucasian morphs, a general bias towards higher similarity to Asian than Caucasian faces was observed in viewers with a variety of races and cultural backgrounds (Chen & Hamilton, 2012). This finding suggests potential influence from fundamental physical feature saliency of faces of different races. Our current finding is consistent with Chen and Hamilton's (2012) results. In addition, we found that participants' perceptual style in viewing own-race faces contributed to this bias effect, with those looking more into the eyes having a higher bias towards Asian/own-race faces. A more eyes-focused eye movement pattern for own-race faces has been associated with better own-race face recognition performance (e.g., Chuk, Chan et al., 2017; Chan et al., 2018; An & Hsiao, 2021; Hsiao, An et al., 2021), suggesting better individualization. Those who were more eyes-focused when viewing own-race faces may have engaged in better individualization, making own-race faces more distinct/away from the average face in face space, and consequently had a stronger bias towards own-race faces than those with less eyes-focused patterns. In contrast, participants' perceptual style in viewing own- or other-race faces was not associated with the other-race advantage in social categorization RT, suggesting that this other-race advantage may be more relevant to our basic-level categorization experience with other-race faces (Ge et al., 2009) unaffected by individual differences in perceptual style.

Regarding the impact of mask use on the social categorization and perceptual style, consistent with our hypothesis, mask use directed participants' attention to the eye region, making their eye movement pattern more eyes-focused, and consequently reduced the other-race effect in eye movement pattern during face reviewing. Nevertheless, mask use was found to have no effect on either the other-race advantage in social categorization RT or the social categorization bias in judging ambiguous faces. This result suggested that these other-race effects in social categorization may stem from the perceptual representations of own- and other-race faces developed over time, and thus could not be changed by transient face covering, in contrast to one's eye movement pattern. Note however that although mask use did not change participants' social categorization RT, it impaired categorization accuracy of other-race (Caucasian) faces but not own-race (Asian) faces. The perceptual representations for own-race faces may be more robust than other-race faces due to our abundant experience in individualizing own-race faces, and thus the accuracy of own-race face judgments is less affected by face covering. In contrast, the other-race advantage in social categorization RT may be related to our basic-level categorization experience with other-race faces (i.e., grouping all Caucasian faces into a category) in contrast to subordinary level categorization or individualization experience with own-race faces (Ge et al., 2009). More specifically, basic-level categorization experience leads to a decrease in within-category variance (i.e., higher similarity) in the perceptual representation for other-race faces, whereas subordinary-level categorization leads to an increase in variance in the perceptual representations within the own-race face category (e.g., Tong et al., 2008; Anaki & Bentin, 2009). Accordingly, our result suggested that mask use, which covers the bottom half of a face, may not significantly change this contrast in within-category variance between our perceptual representations of own- and other-race face categories.

Interestingly, through an explorative analysis, we found that participants with lower social categorization accuracy for masked Caucasian faces had a larger bias towards judging masked ambiguous faces as Asian/own-race. This finding is generally consistent with the argument based on the face space (Tanaka et al., 1998): Those with poorer ability to categorize masked Caucasian faces may have perceived them as less distinctive, leading to a stronger bias towards the relatively more distinctive masked Asian/own-race faces. This finding again suggested that the bias effect was relevant to the development of perceptual representations of own- and other-race faces over time (i.e., face space), and thus was less affected by occlusion of the bottom half of a face by a mask.

Putting these results together, they seemed to suggest that the other-race advantage in social categorization RT and the bias in the perception of ambiguous morphed faces originate from the different perceptual representations developed for own- and other-race faces due to our qualitatively different experiences with them over time. Interestingly, although change in available information due to mask use could significantly change our information acquisition strategy transiently as reflected in eye movement pattern, it did not seem to induce sufficient change in the type of perceptual representation responsible for these social categorization effects. More specifically, information available from the eye region seemed to be sufficient to induce these social categorization effects. This phenomenon contrasted with some other face processing tasks that rely on both the top and bottom halves of a face, such as face recognition or matching. Indeed, mask use has been reported to impair face recognition and holistic face processing as demonstrated in the face inversion effect (e.g., Freud et al., 2020).

Note also that here we found that individuals with a more eyes-focused perceptual style for viewing regular (unmasked) own-race faces had a larger bias in judging ambiguous morphed faces as own-face faces. Nevertheless, changes in eye movement pattern to be more eyes-focused due to mask use did not lead to changes in this bias. This phenomenon suggests again that the bias associated with perceptual style developed over time was unaffected by transient change in eye movement pattern due to mask use.

The current examination of impact of mask use on social categorization focused on Asian participants' perception of Asian and Caucasian faces. Future work may examine whether these findings can be generalized to participants of other races categorizing faces of different races, as the effect of mask use may depend on both an individual's perceptual style and the difference in physical features across faces of different races. For example, both White and East Asian observers were found to spend more time looking at the nose and mouth region of Black faces as compared with White and East Asian faces (Burgund, 2021). Thus, mask use may modulate social categorization effects involving a comparison between Black and White/East Asian faces. It also remains unclear whether the current results can be generalized to other types of social categorization such as gender. Future work will examine these possibilities.

In conclusion, here we showed that people's perceptual style for own-race faces as reflected in eye movement pattern was associated with their bias in social categorization of ambiguous 50% own- and other-race face morphs: a more eyes-focused pattern in viewing own-race faces was associated with a larger bias towards their own race. However, although mask use made participants' viewing pattern more eyes-focused and reduced the other-race effect in eye movement pattern during face viewing, it did not change this bias in judging ambiguous faces, or the other-race advantage in social categorization RT. These results suggest that limited information from the eye region due to mask use may be sufficient to induce these social categorization effects, and that transient eye movement pattern or perceptual input change due to occlusion of facial features by a mask does not modulate these social categorization effects. Thus, effects and biases in social categorization may be impervious to mask use. These findings have important implications for social cognition and social interaction during the pandemic, when mask use is prevalent worldwide.

Acknowledgments

We are grateful to RGC of Hong Kong (Collaborative Research Fund No. C7129-20G to Dr. J. Hsiao) and the National Natural Science Foundation of China (No. 31922089 to Dr. X. Hu). We thank Liu, Jin and Wong, Nicholas Tsz Lok for their help in data collection.

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