Research Article

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Effects of face masks on the appearance of emotional expressions and invariant characteristics

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Abstract: Faces convey a lot of information about a person. However, the usage of face masks occludes important parts of the face. There is already information that face masks alter the processing of variable characteristics such as emotional expressions and the identity of a person. To investigate whether masks influenced the processing of facial information, we compared ratings of full faces and those covered by face masks. 196 participants completed one of two parallel versions of the experiment. The data demonstrated varying effects of face masks on various characteristics. First, we showed that the perceived intensity of emotional expressions was reduced when the face was covered by face masks. This can be regarded as conceptual replication and extension of the impairing effects of face masks on the recognition of emotional expressions. Next, by analyzing valence and arousal ratings, the data illustrated that emotional expressions were regressed toward neutrality for masked faces relative to no-masked faces. This effect was grossly pronounced for happy facial expressions, less for neutral expressions, and absent for sad expressions. The sex of masked faces was also less accurately identified. Finally, masked faces looked older and less attractive. Post hoc correlational analyses revealed correlation coefficient differences between no-masked and masked faces. The differences occurred in some characteristic pairs (e.g., Age and Attractiveness, Age and Trustworthiness) but not in others. This suggested that the ratings for some characteristics could be influenced by the presence of face masks. Similarly, the ratings of some characteristics could also be influenced by other characteristics, irrespective of face masks. We speculate that the amount of information available on a face could drive our perception of others during social communication. Future directions for research were discussed.

Keywords: Face masks; face recognition; emotion recognition; emotional expressions.

1 Introduction

We infer diagnostic information about a person by looking at the face. Especially during pandemic times, parts of the face are frequently occluded resulting in impaired exchange of facial signals. This in turn affects social communication. Studying the evaluation of masked faces thus contributes to an understanding of effects of face masks on social communication. It also ascertains the role of different facial regions used to evaluate a person. We, as visual perception researchers, take advantage of investigating masked faces to generate hypotheses concerning the impact of gaze expressions on social communication.

The eye region is an area of importance within the face. Throughout history, a plethora of sayings often articulate the notion that *the eyes provide a window to the soul*. Examples are inherent not only in cultural messages of the bible, “the eye is the lamp of the body...” (English Standard Version Bible, 2001, Matthew. 6:22), but also lyrically in popular music (e.g., “the fire/spark in your eyes”), or in memorable movie scenes (e.g., “Here’s looking at you, kid.”). The importance of the eye region is also stressed in a variety of fields, including pedagogics (Jarodzka, Scheiter, Gerjets, & Van Gog, 2010), marketing (Pieters & Wedel, 2008; Wedel & Pieters, 2008), or interaction with other species (Kret,

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Tomonaga, & Matsuzawa, 2014). The eye region is important since looking at the eyes of a counterpart is one of the central mechanisms in social interaction. Research shows that looking at the eyes builds and improves the sense of trust (Kret & De Dreu, 2019; Kret, Fischer, & De Dreu, 2015). Looking at the eyes may also decrease how likely a partner is being lied to (Van Breen, De Dreu, & Kret, 2018).

The lower part of the face, i.e., the mouth and nose region, is also relevant for understanding facial signals. The mouth conveys salient signals about happiness through the smile (Calvo & Nummenmaa, 2008). A face continues to look happy due to the smile even if other facial regions do not emote happiness (Calvo & Fernández-Martín, 2013; Calvo, Fernández-Martín, & Nummenmaa, 2013). The jaws and chin also convey information regarding gender (Brown & Perrett, 1993). The shape of the nose can influence the perceived trustworthiness of another person. Specifically, longer noses appear more trustworthy than shorter noses (Linke, Saribay, & Kleisner, 2016). The ethnicity of a person can be derived by estimating face widths and nose sizes (Zhuang, Landsittel, Benson, Roberge, & Shaffer, 2010).

The face confers a variety of information. This includes information about a person's emotion, a person's identity, and a person's characteristics. Faces are emotive. We rely on facial expressions to identify emotions such as fear (Dadds et al., 2006), anger, and sadness (Wegrzyn, Vogt, Kireclioglu, Schneider, & Kissler, 2017). We then interpret the emotional state of another by looking at facial expressions. Emotional expressions are highly variable and can change from one moment to the next (R. J. Harris, Young, & Andrews, 2012; Sato & Yoshikawa, 2004), conveying a wide range of information like happiness, disgust, and sadness (Wegrzyn et al., 2017).

A person's identity is more invariant and stable across time. This is due to our inability to distinguish unfamiliar facial features in a face. Experiments show that participants treated composite faces as a single complete face although the face was edited with facial features from different famous people (Maurer, Le Grand, & Mondloch, 2002). Moreover, changes within a face mostly do not break face perception except when the change involves inverting individual facial features (Young, Hellawell, & Hay, 2013). Such findings imply that we perceive faces holistically using valid eyes-nose-mouth configurations. Once the eyes-nose-mouth configuration is established, face processing steps further to determine the identity of the face we are observing. Specifically, faces can be effectively recognized by looking slightly below the eyes (Peterson & Eckstein, 2012). The eyes and the eye region thus provide important cues for determining the identity of a face and recognizing it (Royer et al., 2018; Vinette, Gosselin, & Schyns, 2004).

The face also communicates trait-like characteristics about a person. Certain facial features like light skin tone, facial symmetry, and specific mouth/nose outlines are often used to judge whether a person appears attractive, trustworthy, or approachable (Linke et al., 2016; Perrett et al., 1999; R. Russell, 2003; Scheib, Gangestad, & Thornhill, 1999; Todorov, Baron, & Oosterhof, 2008; Vernon, Sutherland, Young, & Hartley, 2014). Invariant characteristics like sex and age, together with variable emotional expressions, are also known to influence the inference of these trait-like characteristics. Attractiveness is influenced by the face's sex because feminine-looking faces appear more attractive (Rhodes, Hickford, & Jeffery, 2000). Age alters the perceived facial attractiveness such that older faces look less attractive (Korthase & Trenholme, 1982). A smiling face often appears more attractive and pleasant (Otta, Abrosio, & Hoshino, 1996), whereas an angry face looks less approachable (M. L. Willis, Palermo, & Burke, 2011). Genuine smiles with a long onset to the smile apex, a short smile apex duration, and a long offset from the smile apex, appears more trustworthy than smiles with short onsets and offsets, and long apex durations (Krumhuber & Kappas, 2005; Krumhuber et al., 2007). Collectively, these studies exemplify how invariant characteristics and variable emotional expressions surrounding a person affect trait-like characteristics. However, these studies are often conducted on full faces. Hence, how certain parts of the face influence the perception of these characteristics remains unclear. Understanding what is obtained when viewing faces with and without face masks contributes both practically in current pandemic times and scientifically to a deeper knowledge of the roles of various facial regions in social communication.

2 Effects of face masks

Faces are sometimes partially occluded by apparel like scarves and religious coverings. This limits our abilities to recognize or to relate to others (Kret & De Gelder, 2012; Kret & Fischer, 2018). The eyes, nose, and mouth regions convey various information about a person. However, most of the information conveyed by the nose and mouth region is diminished once a face mask is worn. The effects of face masks on face perception have been studied in medical

settings (Wong et al., 2013), religious contexts (Kret & De Gelder, 2012), and in more recent times, the pandemic (Spinelli & Pellino, 2020). Face masks occlude the mouth and nose regions which help us recognize faces and facilitate social interaction (Seamon, Stolz, Bass, & Chatinover, 1978). Thus, face masks forces us to rely on unobstructed areas on the face, such as the eyes and eye region, for communication.

Face masks may affect how we perceive certain characteristics about a person when viewing the face. When a full face is shown, one may easily identify the sex or age of another person by observing the jaws (Brown & Perrett, 1993) and wrinkles (Nkengne et al., 2008), respectively. A recent study suggested that recognizing such invariant characteristics may be impaired once the full face is partially occluded by face masks (Freud, Stajduhar, Rosenbaum, Avidan, & Ganel, 2020). This is because face masks obstruct the eyes-nose-mouth configuration. The eyes-nose-mouth configuration is important in face recognition. Some evidence revealed that minor alterations to the eyes-nose-mouth configuration diminishes the recognizability of famous faces (Tanaka & Sengco, 1997). Thus, face masks may influence how we perceive some characteristics about a person.

Face masks also affect our ability to recognize emotional expressions. The efficacy of recognizing variable emotional expressions is reduced for faces wearing face masks (Carbon, 2020). The study demonstrated that participants were more inaccurate at distinguishing emotional facial expressions with masks. Furthermore, participants often misattributed the emotions of masked faces such that masked emotional faces were often perceived to emote neutral expressions.

One might extrapolate and argue that face masks influence face processing because face masks impact our ability to recognize facial identity and emotional expressions accurately. However, such considerations must be carefully investigated since facial emotion recognition relies on facial features that differ from those used to recognize identity (Bradley & Lang, 1994). According to the literature, face identification is a holistic process where the whole face is evaluated (Richler, Mack, Gauthier, & Palmeri, 2009). Holistic processing facilitates face recognition (Richler, Cheung, & Gauthier, 2011). Emotional expression, however, may not be processed in the same holistic manner. Local processing of specific facial regions facilitates emotion recognition (Martin, Slessor, Allen, Phillips, & Darling, 2012). Negative emotions require local processing of certain facial regions whereas positive emotions can be processed globally (Srinivasan & Hanif, 2010). Inducing negative emotions in observers also reduces the extent of holistic face processing when viewing chimeric faces (Curby, Johnson, & Tyson, 2012).

For the current study, we compared the evaluation of various characteristics between no-masked faces to masked faces to better grasp the characteristics inferred from the unobstructed regions of masked faces. The regions of the upper face include the eyes, the eye region, and the forehead. We were interested in comparing the effects of face masks on variable emotional expressions, invariant characteristics, trait-like characteristics, and the interactions between these constructs. We measured the ratings of arousal and valence (as variable emotional expressions), sex and age (as invariant characteristics), and for attractiveness, trustworthiness, and approachability (as trait-like characteristics). These ratings were shown for neutral faces. Emotional expressions were selected based on opposite pairs. The opposite expressions should also be comparably equal in arousal levels. According to J. A. Russell (1980), opposite emotion pairs with similar arousal levels were happy and sad. Thus, we additionally measured ratings for happy and sad expressions. Arousal and valence were rated using the two dimensions arousal and valence on the Self-Assessment Manikin (SAM) scale (Bradley & Lang, 1994).

Are the perceived characteristics of another person the same for no-masked and masked faces? We expected that face masks would reduce the perceived intensity of variable emotional expressions, and impede judgements of invariant characteristics, and trait-like characteristics. A smile biases the perceived happiness of a face. The smile also influences how trustworthy and approachable a face appears. When the smile is occluded by the face masks, the intensity of the perceived happiness should decrease. The face would also appear less trustworthy and less approachable. Similarly, an emotive face is arousing in comparison to a neutral face. Face masks which occlude emotional expressions should look less emotive and less arousing. The jaws and chin convey information about a person's gender. Moreover, gender influences the perceived attractiveness of the face. As such, face masks should reduce the accuracy for identifying the face's sex and lower the perceived attractiveness. Wrinkles communicate age. Since this region is not occluded by face masks, age ratings should not differ between masked and no-masked faces.

3 Methods

3.1 Participants

The sample consisted of 196 participants (90 females, 99 males, three others). Participants were mostly young adults: 124 (63.30 %) participants reported being below 30 years, 35 (17.90 %) below 40 years, 21 (10.70 %) below 50 years, and 16 (8.10 %) above 50 years. Most participants were Asians ($n = 113$, 57.70%), followed by other ethnicities ($n = 48$, 24.50 %), and Caucasians ($n = 35$, 17.90 %). Participants were randomly assigned to one of two parallel versions of the test; $N = 94$ participants (48%) completed Version A, and $n = 102$ (52%) completed Version B. Participants provided informed consent before starting the data collection. The experiment was in accordance with the declaration of Helsinki.

3.2 Stimuli

Eight models (four males, four females; among each of them two Asian and two Caucasian faces) were chosen from the Montreal set of facial displays of emotion data base (Beaupré, Cheung, & Hess, 2000). Each model exhibited happy, neutral, and sad facial expressions. All faces were greyscale images. We then added face masks to all faces using Photoshop. Figure 1 illustrates some faces with neutral expressions used in the study.

Faces presented to each participant had thus either a mask or were unmasked. From here-on, we refer to the faces as no-masked and masked faces.

Figure 1: Sample neutral faces used in the current study. Eight faces were used in the experiment. Four of the faces were shown here. There was a no-masked and a masked version for each face.

3.3 Design

The experiment consisted of two blocks. The purpose of Block 1 was to measure invariant characteristics such as physical appearance (sex, age) and trait-like characteristics (attractiveness, trustworthiness, approachability) in neutral face stimuli. Ratings in Block 1 (except for age) were performed on a four-point Likert scale (Figure 2). The scale for sex ranged from female to male, where 1 = surely male and 4 = surely female. Sex was later recoded during analysis such that higher values indicated better accuracies. Scale values for trait-like characteristics ranged from lowest to highest,

where 1 = least and 4 = most (Figure 2). The scale for arousal ranged from calm to excited, where 1 = calm, 3 = neutral, and 5 = excited. The scale for valence ranged from happy to sad, where 1 = happy, 3 = neutral, and 5 = sad.

In Block 1, the same face was either presented only with a mask or only without a mask. In Block 2, emotional expressions were to be rated. Therefore, the faces were presented with a happy, a neutral, and a sad expression. Unmasked faces of Block 1 were masked faces in Block 2 and vice versa. Emotional expressions were to be rated using the Self-Assessment Manikin (SAM) scales of valence and arousal. These SAM-ratings were to be performed on a five-point Likert scale (see Figure 2). Participants always began with Block 1 before proceeding to Block 2.

Neutral faces in Block 1 consisted of 4 models (2 females, 2 males) × 2 Mask (no-masked, masked) = 8 faces. For each rating, faces were presented in random order. For each of the eight faces, participants evaluated five characteristics; sex, age, trustworthiness, attractiveness, and approachability, which sums up to a total of 8 × 5 = 40 trials which had to be performed in Block 1. Except age which was rated using a 5-point Likert scale, all characteristics were rated on a 4-point Likert scale. There were two versions of the study; masked models in Block 1 of Version A were no-masked models in Block 1 in Version B, and vice versa.

Figure 2: Examples of Likert and Self-Assessment manikin (SAM) scale used in the study. Scales in grey are used to rate invariant characteristics, such as sex, age, attractiveness, and trustworthiness. The SAM scales include pictorial illustrations.

In Block 2, happy, neutral, and sad faces were presented. Faces which were masked in Block 1 were unmasked in Block 2, and vice versa. That is again, two female and two male models were presented either no-masked or masked so that only half of the faces presented wore a mask. Each face in Block 2 also exhibited one of three expressions (happy, neutral, sad). Thus, in Block 2, the number of depicted faces sums up to 4 (models) × 2 (mask) × 3 (expressions) = 24 faces. Like in Block 1, for each rating, faces were presented in random order. That is, participants evaluated valence

and arousal of the faces separately. Participants gave their ratings using a 5-point SAM rating scale. Hence, participants completed a total of $24 \times 2 = 48$ trials in Block 2.

In the two blocks per version, different facial expressions were displayed during the study. Participants saw only neutral faces in Block 1. In Block 2, participants saw happy, neutral, and sad faces. For both versions, masked faces in Block 1 were unmasked in Block 2. There were two versions of the study. In Version A, two male and two female faces were presented with masks in Block 1, and the remaining four were presented as no-masked faces in Block 1. Face models which were masked in Version A were unmasked in Version B, and vice versa. The experiment was programmed with the builder function in PsychoPy2 and administered online via pavlov.org (Peirce et al., 2019).

Procedure

The experiment was conducted entirely online without any supervision from a research assistant. Participants received an online link via the student mailing lists at Ulm University. In addition, students were encouraged to share the study link using social media accounts to ask for participation. Informed consent was presented prior to the start of the experiment, and participants were informed that they could abandon the study at any time. Participants provided consent by press before the instructions were shown. Figure 3 illustrated the procedure.

Participants were instructed to rate the faces regarding invariant and trait-like characteristics (Block 1) and regarding arousal and valence as emotional expressions (Block 2). Participants made a key press to proceed with one practice trial. During the practice trial, participants rated the attractiveness of a female Asian face without mask using a 4-point Likert scale. The face shown in the practice trial never appeared in the remaining experiment. The practice trial ended once participants gave a response.

Block 1 began with an instruction screen before rating each invariant and trait-like characteristics. Participants were instructed which characteristics they would rate for the subsequent faces. The rating scale was also shown together with the instructions. For each of the following trials, a face appeared in the center of the screen with a prompt “This person looks ...” positioned below the image. Participants then responded with the respective 4-point or 5-point Likert scale by selecting the options with a key press. The next image was presented immediately once participants gave a rating. Block 1 lasted about five minutes.

Figure 3: Procedure of the experiment in Version A. Masked faces in Version A were no-masked ones in Version B. The face used for the practice trial never appeared in the remaining experiment. The scales used in the illustration were attractiveness (block 1) and arousal (block 2). Masked faces in block 1 were no-masked faces in block 2, and vice versa.

Block 2 commenced immediately after Block 1. On the first instruction screen, participants were told that the scale used to rate faces were 5-point Likert scales. After acknowledging the instructions via key press, participants saw a screen to remind them of the SAM scale to rate. This screen appeared before participants rated either arousal or valence for subsequent faces. For each trial, a face, like in Block 1, appeared in the center of the screen with the prompt “This person looks ...” positioned below the image. Participants gave their response on the 5-point SAM scale by key press. The next image was presented immediately after participants made their response. Block 2 lasted approximately three minutes. At the end of Block 2, participants gave their age, ethnicity, and gender. Altogether, participants spent 10 minutes conducting the experiment.

3.4 Analysis

Data from one participant was excluded from the analysis because the participant always pressed the same button. All analyses were conducted in SPSS (IBM SPSS Statistics for Windows, Version 26.0). The dependent variables (DVs) for emotional expression were arousal and valence, DVs for invariant characteristics were age and sex; and DVs for trait-like characteristics were trustworthiness, attractiveness, and approachability. Effects of face masks on emotional expressions were analyzed using a 2×3 repeated measures ANOVA with the factors mask (2: no-masked, masked) and facial expressions (3: happy, neutral, sad). We ran paired-samples *t* tests to evaluate the effects of face masks on invariant characteristics and trait-like characteristics DVs. Thus, there were five comparisons (two invariant characteristics + three trait-like characteristics) between no-masked and masked faces. Since it is unclear whether the DVs measure different characteristics, we conservatively corrected for multiple comparisons using Bonferroni-corrected $\alpha = .05 \div 5 = .01$. Thus, *p*-values $\leq .01$ were regarded as significant. Post-hoc *t*-tests for arousal and valence were conducted if there were significant interaction effects. The comparisons were between masked and no-masked ratings per facial expressions (Happy, neutral, sad). Multiple comparisons were corrected using Bonferroni corrected $\alpha = .05 \div 3 = .0167$. In addition, correlations between all ratings, for no-masked and for masked faces, were analyzed. This was done by computing the means of each rating for no-masked and masked faces across both versions respectively. For example, valence (happy) rating for no-masked faces were calculated by averaging valence ratings of all no-masked faces showing happy expressions in Version A and Version B, age rating for masked faces were computed by taking the mean of masked faces in Version A and masked faces in Version B, etc. We then ran Fisher’s Z tests to evaluate if the correlation coefficients differed between no-masked and masked faces. This determined if the correlations between variables differed for no-masked and masked faces.

4 Results

4.1 Emotional expression

Valence ratings were statistically different between the different facial expressions (Figure 4a), $F(2, 189) = 356.53$, Wilks $\Lambda = .21$, $p < .001$, partial $\eta^2 = .79$. The data indicated that happy faces ($M = 1.66$, $SD = \pm .72$) were rated happier than neutral ($M = 3.07$, $SD = \pm .34$, $p < .001$), and sad ($M = 4.18$, $SD = \pm .70$, $p < .001$) faces. Neutral faces were rated less happy than happy ($p < .001$) faces, and more happy than sad faces ($p > .001$). Valence ratings did not differ significantly between no-masked and masked faces, $F(1, 190) = 2.05$, Wilks $\Lambda = .98$, $p > .05$, partial $\eta^2 = .02$. There was a significant interaction between masks and facial expressions, $F(2, 189) = 38.21$, Wilks $\Lambda = .71$, $p < .001$, partial $\eta^2 = .29$. Post-hoc tests showed that participants rated no-masked happy faces ($M = 1.49$, $SD = \pm .85$) happier than masked happy faces ($M = 1.82$, $SD = \pm .71$), $t(190) = -7.57$, $SD = \pm .62$, $p < .001$ (Bonferroni corrected $\alpha = .0167$). No-masked sad faces ($M = 4.22$, $SD = \pm .75$) were not any sadder than masked sad faces ($M = 4.14$, $SD = \pm .74$), $t(190) = -2.31$, $SD = \pm .51$, $p > .0167$ (Bonferroni corrected $\alpha = .0167$). No-masked neutral faces ($M = 3.15$, $SD = \pm .39$) were rated less happy than masked neutral faces ($M = 2.99$, $SD = \pm .44$), $t(190) = 4.84$, $SD = \pm .51$, $p < .001$ (Bonferroni corrected $\alpha = .0167$).

Figure 4: Ratings for a) valence and b) arousal across happy, neutral, and sad facial expressions, separately for no-masked (orange bars) and masked faces (blue bars). In a), lower scores indicate happier and higher scores indicate sadder. In b) higher scores reflect greater arousal. Error bars indicate standard error of means (SEM). *** $p \leq .001$, ** $p \leq .01$, * $p \leq .05$.

Arousal ratings were statistically different between the different facial expressions, $F(2, 189) = 150.71$, Wilks $\Lambda = .39$, $p < .001$, partial $\eta^2 = .61$, in that happy faces were rated the highest arousal ($M = 4.00$, $SD = \pm .91$) than neutral ($M = 2.68$, $SD = \pm .54$, $p < .001$) or sad ($M = 2.72$, $SD = \pm 1.10$, $p < .001$) faces. Arousal ratings did not differ between neutral and sad faces ($p > .05$). Arousal ratings differed significantly between no-masked and masked faces (Figure 4b), $F(1, 190) = 4.96$, Wilks $\Lambda = .98$, $p < .05$, partial $\eta^2 = .03$. The data indicated that no-masked faces ($M = 3.16$, $SD = \pm .49$) appeared more aroused than masked faces ($M = 3.10$, $SD = \pm .46$). There was a significant interaction between masks and facial expressions, $F(2, 189) = 31.26$, Wilks $\Lambda = .75$, $p < .001$, partial $\eta^2 = .25$. Post-hoc tests revealed that no-masked happy faces ($M = 4.20$, $SD = \pm 1.06$) appeared more aroused than masked happy ones ($M = 3.80$, $SD = \pm .90$), $t(190) = 7.79$, $SD = \pm .72$, $p < .001$ (Bonferroni corrected $\alpha = .0167$). No-masked neutral faces ($M = 2.60$, $SD = \pm .66$) appeared less aroused than masked neutral faces ($M = 2.76$, $SD = \pm .58$), $t(190) = -3.59$, $SD = \pm .61$, $p < .001$ (Bonferroni corrected $\alpha = .0167$). There were no differences in arousal ratings between no-masked sad faces ($M = 2.69$, $SD = \pm 1.13$) and masked sad faces ($M = 2.75$, $SD = \pm 1.17$), $t(190) = -1.33$, $SD = \pm .65$, $p > .05$.

In short, face masks reduced the variability of rated emotional expressions of valence and arousal. The reductions were clearly observed for happy faces, slightly for neutral faces, but not for sad faces.

4.2 Invariant characteristics

Face masks contributed significantly to ratings of the face's sex (Figure 5a), $t(190) = 3.11$, $SD = \pm .44$, $p < .01$, Bonferroni-corrected $\alpha = .01$. The data showed that participants rated no-masked faces ($M = 3.76$, $SD = \pm .43$) more accurately than masked faces ($M = 3.66$, $SD = \pm .46$). Mask was a significant factor for age ratings (Figure 5b), $t(190) = -7.21$, $SD = \pm .69$, $p < .001$. The data indicated that participants rated no-masked faces ($M = 1.99$, $SD = \pm .59$) younger than masked faces ($M = 2.36$, $SD = \pm .$). In short, face masks altered invariant characteristics. It was more difficult to identify if a masked face was male or female. Masked faces also looked older than no-masked ones.

Figure 5: Averaged ratings for invariant characteristics a) sex and b) age. Higher scores in a) indicate higher accuracies at identifying the face's sex, while higher ratings in b) indicate older age. *** $p \leq .001$, ** $p \leq .01$, * $p \leq .05$.

4.3 Trait-like characteristics

Face masks influenced attractiveness ratings (Figure 6), $t(190) = 4.55$, $SD = \pm .62$, $p < .001$. Participants rated no-masked faces ($M = 2.65$, $SD = \pm .48$) as more attractive than masked faces ($M = 2.45$, $SD = \pm .47$). However, masks did not affect ratings for trustworthiness (Figure 6), $t(190) = 1.06$, $SD = \pm .62$, $p > .05$. Ratings did not differ for no-masked ($M = 2.64$, $SD = \pm .47$) and masked ($M = 2.60$, $SD = \pm .46$) faces. Face masks did not affect the ratings for approachability (Figure 6), $t(190) = 1.90$, $SD = \pm .65$, $p > .05$. Approachability ratings did not differ between no-masked ($M = 2.70$, $SD = \pm .50$) and masked ($M = 2.61$, $SD = \pm .46$) faces. In short, masked faces looked less attractive. However, face masks did not affect ratings of trustworthiness and approachability.

Figure 6: Averaged of trait-like characteristics ratings for Attractiveness, Trustworthiness, and Approachability. Higher ratings indicate greater agreement to the perceived trait-like characteristics. *** $p \leq .001$, ** $p \leq .01$, * $p \leq .05$.

4.4 Correlation analysis

Trait-like characteristics could be influenced by invariant characteristics and emotional expressions. We evaluated the extent of the influence in a correlation analysis. Figure 7 depicts the correlations between the variables for no-masked (Figure 7a) and masked faces (Figure 7b).

Figure 7: Correlations between variables for a) no-masked and b) masked faces. Color indicates correlation coefficient; Pearson's *r*. Non-significant coefficients are excluded to reduce visual clutter. *** $p \leq .001$, ** $p \leq .01$, * $p \leq .05$.

For no-masked faces, the three trait-like characteristics were highly intercorrelated. Attractiveness was correlated to trustworthiness ($r = .46, p < .001$) and approachability ($r = .43, p < .001$). Trustworthiness was correlated to approachability ($r = .49, p < .001$). One of the invariant characteristic was correlated to all three trait-like characteristics. Sex was correlated to attractiveness ($r = .21, p < .01$), trustworthiness ($r = .23, p < .001$), and approachability ($r = .22, p < .01$). Emotional expressions for arousal were correlated to the trait-like characteristics. Arousal (happy) was correlated to attractiveness ($r = .21, p < .01$) and approachability ($r = .21, p < .01$). Arousal (sad) was negatively correlated to attractiveness ($r = -.22, p < .01$).

For masked faces, the three trait-like characteristics were highly intercorrelated. Attractiveness was correlated to trustworthiness ($r = .48, p < .001$) and approachability ($r = .40, p < .001$). Trustworthiness was correlated to approachability ($r = .55, p < .001$). Invariant characteristics were correlated to trait-like characteristic ratings. Sex was correlated to trustworthiness ($r = .25, p < .001$). Age was negatively correlated to attractiveness ($r = -.21, p < .001$) and trustworthiness ($r = -.21, p < .001$). Arousal (sad) was correlated to trustworthiness ($r = .15, p < .05$).

The Fisher's Z test results and coefficients were presented in Table 1. The following characteristic pairs between no-masked and masked ratings differed significantly: sex and arousal (sad), age and attractiveness, age and trustworthiness, age and arousal (sad), attractiveness and arousal (sad), trustworthiness and arousal (sad), approachability and arousal (sad), arousal (happy) and arousal (neutral), arousal (neutral) and arousal (sad), arousal (sad) and valence (neutral), valence (happy) and valence (neutral), and valence (happy) and valence (sad).

Table 1: Fisher's Z test between no-masked and masked faces.

	Sex	Age	Attractive- ness	Trust- worthiness	Approacha- bility	Arousal			Valence		
						Happy	Neutral	Sad	Happy	Neutral	Sad
Sex	-										
Age	.61	-									
Attractiveness	1.08	2.80**	-								
Trustworthiness	-.20	2.66**	-.21	-							
Approachability	1.06	1.79	.29	-.92	-						
Arousal											
Happy	1.91	-.88	1.83	1.45	1.65	-					
Neutral	-.03	1.55	1.27	1.93	1.66	-2.14*	-				
Sad	-4.02 ***	2.05*	-3.47 ***	-2.08*	-2.03*	-.65	2.83**	-			
Valence											
Happy	.27	1.17	-1.58	-.84	-.87	-.05	1.36	.60	-		
Neutral	-1.63	1.06	-.33	-.18	.22	1.33	-1.33	-2.37*	-2.06*	-	
Sad	.78	-.88	.90	1.51	1.52	.78	-.71	-.53	-2.73**	1.14	-

*** $p \leq .001$, ** $p \leq .01$, * $p \leq .05$.

The relationships between trait-like characteristics, invariant characteristics, and emotional expressions did not appear different regardless of face masks. The correlations indicated that trait-like characteristics were influenced by invariant characteristics and emotional expressions. A face could still appear trustworthy if participants were accurate at judging the face's sex. Similarly, the more aroused a sad face appeared, the more trustworthy it seemed. Younger faces also looked more attractive and trustworthy. The more aroused a happy face looked, the higher the attractiveness and approachability. Similarly, the less aroused a sad face looked, the more attractive the face was.

In summary, face masks may not alter certain properties used to evaluate the characteristics of a face. Furthermore, face masks did not prevent face processing from occurring entirely.

5 Discussion

We examined the characteristics communicated by the upper facial region around the eyes by comparing ratings between masked and no-masked faces. Our results indicated that face masks impacted the ratings for variable emotional expressions, invariant characteristics, and trait-like characteristics. Specifically, when compared to no-masked faces, masked faces appeared less intense in valence, the sex of masked faces were rated less accurately, and masked faces appeared less attractive. Correlation analysis showed that significant relationships between the characteristics in no-masked and masked faces appeared different initially. However, there was no empirical evidence that the correlation coefficients differed between no-masked and masked faces.

Face masks reduced the evaluation of emotional expression intensity. This meant that an expression's appearance would be perceived as less intense due to face masks. Existing studies showed that the emotions of masked faces were often misattributed as neutral expressions (Carbon, 2020). Our results expanded on previous findings using discrete emotions. We showed that the emotional expressions were rated more neutral and averaged even after adopting dimensional approach measurements using the SAM ratings. Interestingly, this effect was most pronounced in happy facial expressions, but less so in neutral, and non-existent for sad expressions. Thus, it might be necessary to exaggerate facial expressions whenever the face is covered to convey the same emotional intensity as a full face.

It comes as no surprise that face masks would reduce the perceived intensity of happy expressions. There is often an advantage at identifying a happy face (Farran, Branson, & King, 2011; Kirita & Endo, 1995). This advantage becomes evident when a smile is shown (Calvo et al., 2013). The strong influence of the smile persists to convey a happy expression even if the face or other facial features are inverted (Calvo & Fernández-Martín, 2013; Shimamura, Ross, & Bennett, 2006). Hence, happy expressions were perceived as less intense when face masks covered this important facial feature.

Our data showed that participants could still rate happy expressions for masked faces, albeit to a lesser degree. It was not by chance that participants could somewhat distinguish happy expressions behind masked faces. There is evidence that the eyes are involved at conveying happiness to a lesser extent, even when the full face is shown (Calvo, Álvarez-Plaza, & Fernández-Martín, 2017; Leppänen & Hietanen, 2007). Another observation from our data was that face masks did not play a strong role in influencing perceived neutral and sad expressions. This could be due to the regions of the face which convey such expressions. According to the literature, negative emotions like sadness are often inferred from the eye regions (Beaudry, Roy-Charland, Perron, Cormier, & Tapp, 2014; Eisenbarth & Alpers, 2011). Since face masks do not occlude the eyes and eye regions, participants were not significantly influenced by masks when rating sadness intensities.

The face communicates by large-scale mimic as well as by tiny movements of some muscles (e.g. pupil size changes close to perceptual threshold). On the one hand, regarding the models, we cannot be certain about these tiny movements: When models have to simulate emotional states, it is unclear whether their expressions include all the tiny facial information as in real life. On the other hand, regarding the observers, the screen size and thus, the displayed size of the images, has not been controlled for. Hence, whether we might further have been able to detect potential effects of such tiny facial information is unclear. The current correlational analysis may suggest that observers relied more on global physical features (as, e.g., the age which may be inferred from the hairstyle and -color) than on tiny local information. Hence, to infer details about the contribution of the eye region to the current effects, one should also occlude the forehead and hair region.

Our findings should be interpreted with the assumption that the facial expressions depicted true emotions at the point the expression was photographed. According to the literature, the Duchenne smile is characterized by a contraction of the orbicularis oculi and pars lateralis muscles around the eye region. These muscle contractions can signify genuine and enjoyable smiles (Frank & Ekman, 1993; Frank, Ekman, & Friesen, 1993; Mehu, Grammer, & Dunbar, 2007; Ruch & Ekman, 2001). Faces showing the Duchenne smile are often rated more positively than faces without it (Gunnery & Ruben, 2016). However, the assumption that Duchenne smiles are believed to distinguish true and false smiles should be considered carefully. This assumption might be misleading when slight details of the mimics are neglected. For example, some individuals mimic Duchenne smiles to convey false emotions. These individuals do not experience true enjoyment (Gunnery, Hall, & Ruben, 2013). Therefore, respective doubts about the extent to which emotional expressions from face databases can be representative of certain emotions may still be inherent and affect the generalization of (not only) the current findings.

Face masks do not impede all forms of social communication involving the face. While up to half the face was occluded by the mask, the occlusion simply altered the perception of various characteristics surrounding the face. The influence of invariant characteristics and emotional expressions on the perceived trait-like characteristics when looking at a face remains important, even if the face was occluded by face masks (Figure 7). When faces appear younger, so does the perceived attractiveness and trustworthiness of the face. Such relationships implied that face perception stayed possible despite the partial occlusion of the eyes-nose-mouth configuration. Importantly, the characteristics of a face may be perceived differently when the perception of other characteristics changes, irrespective of face masks. This evidence also suggests that the unobstructed regions of the face continue to convey characteristics about the face since participants did not suddenly rate masked faces meaninglessly or randomly.

The available region of a face facilitates social communication. One form of communication derived from the face is “first impressions”. First impressions are what we perceive about another by merely looking at them (Todorov, Pakrashi, & Oosterhof, 2009; J. Willis & Todorov, 2006). Impressions have lasting effects since we subsequently alter our behaviors around others (Dougherty, Turban, & Callender, 1994; M. J. Harris & Garriss, 2008). Although face masks occlude a large portion of the face, we speculate that the unobstructed area of the face continues to convey information such as first impressions for social communication. This speculation is drawn from the evidence that it is possible to extract impressions from briefly presented low-spatial frequency faces presented at 39 ms (Bar, Neta, & Linz, 2006). Additionally, impressions can also form when an observer is unaware of seeing the face (Anderson, Siegel, White, & Barrett, 2012). What lingers on faces wearing face masks is extracted to create an impression about the face. Our data could have hinted at this speculation based on the correlations. One might argue that observers used different characteristics to evaluate the face depending on which information was left available on the face. However, we could not draw such conclusions since the correlation coefficients did not reveal consistent differences between no-masked and masked faces. We also did not measure explicitly which information participants used to evaluate different characteristics. Nonetheless, this motivates future research to identify the extent the non-occluded areas of the face have on the perceived characteristics of others.

Memory biases could have influenced how participants rated masked and no-masked faces. The impression we obtained from, or the traits we assigned to, a stranger’s face stays relatively stable across time. Furthermore, we develop greater confidence in our impressions or trait assignments the longer the face is visible (J. Willis & Todorov, 2006). In our experiment, participants saw the same face multiple times while rating various characteristics. It was likely that the impression derived from the initial exposure of the faces remained stable throughout the experiment. Participants could have remembered the impressions to guide their subsequent judgments. Thus, the responses would be biased, even when the faces switched from masked to no-masked (or vice versa) between block 1 and block 2. Future experiments could control for memory biases by introducing new faces for different characteristics.

Regarding the practical impact of the current findings, one might reflect whether it is more useful to enable social interaction in presence by masking the faces. The alterations of perceived characteristics for masked faces could facilitate certain forms of social interactions. For example, the perceived characteristics of familiar faces might differ grossly with those of unfamiliar faces. According to the literature, there is a recognition advantage for the eyes-nose-mouth region of familiar faces (Young, Hay, McWeeny, Flude, & Ellis, 1985). Unfamiliar faces are also processed differently from familiar ones (Megreya & Burton, 2006; Weibert & Andrews, 2015). From these findings, one may speculate that face masks would not affect the judgment of familiar faces more than for unfamiliar faces. One might also investigate the extent different facial signals contribute to the perception of such characteristics. For instance, facial signals like pupillary

movements or mouth puckering require spatial resolutions which are only available at close distances. The impact of such signals which are close to threshold is still unclear for a lot of scenarios. As more businesses and classrooms meet online due to the pandemic, one could also investigate the impacts of face masks on online environments and determine if face masks impair online social communications.

In sum, the current findings stress the notion of several important aspects of the face in social communication: by using the dimensional SAM approach, we showed that emotional expressions appear less extreme for masked faces than for no-masked faces. The face's sex was more difficult to evaluate for masked faces than for no-masked ones. Face masks also affected the appearance of age and attractiveness. Collectively, the contribution of the upper face region to social communication was successfully studied using face masks. Hence, our data demonstrated a potential of using face masks for the study of social communication in theoretical and applied aspects.

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