Research Square

Preprints are preliminary reports that have not undergone peer review. They should not be considered conclusive, used to inform clinical practice, or referenced by the media as validated information.

Wearing N95, Surgical and Cloth Face Masks Compromises the Communication of Emotion

Andrew Langbehn (alangbe1@utk.edu)
University of Tennessee - Knoxville https://orcid.org/0000-0001-8986-2165

Dasha Yermol
University of Wisconsin - Madison

Fangyun Zhao
University of Wisconsin - Madison

Christopher Thorstenson
University of Wisconsin - Madison; Wisconsin Institute for Discovery

Paula Niedenthal
University of Wisconsin Madison

Article

Keywords: Emotional Conveyance, Facial Action, Face Masking, Smile Types

Posted Date: December 23rd, 2020

DOI: https://doi.org/10.21203/rs.3.rs-133686/v1

License: This work is licensed under a Creative Commons Attribution 4.0 International License.
Read Full License

Wearing N95, Surgical and Cloth Face Masks Compromises the Communication of Emotion

Andrew T. Langbehn, Dasha A. Yermol, Fangyun Zhao, Christopher A. Thorstenson, Paula M. Niedenthal*

[a]Department of Psychology, University of Tennessee-Knoxville, Knoxville, TN 37996; USA

[b]Department of Psychology, University of Wisconsin-Madison, Madison, WI 53706; USA

[c]Wisconsin Institute for Discovery, University of Wisconsin-Madison, Madison, WI 53706, USA

*Corresponding Author: Paula M. Niedenthal, email: pneidenthal@wisc.edu

Abstract

According to the familiar axiom, the eyes are the window to the soul. However, wearing masks to prevent the spread of COVID-19 involves occluding a large portion of the face. Do the eyes carry all of the information we need to perceive each other's emotions? We addressed this question in two studies. In the first, 162 Amazon Mechanical Turk (MTurk) workers saw videos of human faces displaying expressions of happiness, disgust, anger, and surprise that were fully visible or covered by N95, surgical, or cloth masks and rated the extent to which the expressions conveyed each of the four emotions. Across mask conditions, participants perceived significantly lower levels of the expressed (target) emotion and this was particularly true for expressions composed of greater facial action in the lower part of the faces. Furthermore, higher levels of other (non-target) emotions were perceived in masked compared to visible faces. In the second study, 60 MTurk workers rated the extent to which three types of smiles (reward, affiliation, and dominance smiles), either visible or masked, conveyed positive feelings, reassurance, and superiority. They reported that masked smiles communicated less of the target signal than visible faces, but not more of other possible signals. Political attitudes were not systematically associated with disruptions in the processing of facial expression caused by masking the face.

Introduction

If you feel as though life during the COVID-19 pandemic is flat and lacking in the full range and complexity of social stimulation, that's because it is. People are used to seeing each other's faces signaling states as varied as disgust, awe, effort, frustration, and attraction. But since the pandemic began, we have seen fewer faces, and the faces we do see are often partially covered by masks.

Starting in the spring of 2020, the Centers for Disease Control and Prevention of the United States (CDC) has recommended the use of face-covering masks to protect against the spread of the COVID-19 virus (1). Similar recommendations have also been adopted by the World Health Organization (WHO; 2) (Up to date recommendations available at https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public/when-and-how-to-use-masks). While the health benefits are undeniable, a potential adverse effect of the use of face masks is that it reduces the amount of information conveyed by the face.

The overall loss of visual information is significant. Human faces are composed of 43 individual muscles that possess the unique property of being connected to skin and other muscles, but not to bone. The muscles can contract in a variety of combinations, producing the temporary changes in the superficial geometry of the face that we know as facial expressions (3). Facial expressions are nuanced social signals. They efficiently communicate behavioral intentions, attitudes, as well as emotional states (4-6), and a perceiver's ability to accurately extract meaning from facial expressions is necessary for successful social interaction (7-9).

Is a person's ability to accurately process the meaning of facial expression compromised when the perceived face is covered by a mask? The question must be answered empirically because the possibility that people's internal states and momentary intentions can be perceived from the eyes alone is a plausible alternative hypothesis (10). The present studies investigated the perception of emotion in dynamic human faces that were fully visible versus faces that were covered by the most common types of face mask in use during the COVID-19 pandemic: N95, surgical, and cloth. We explored the effects of mask-wearing on both expressions of some so-called basic emotions (11) as well as more nuanced variations on the human smile (12).

Perceiving emotions in facial expressions relies on at least three processes that can be hampered by masks (13). First, visual information from faces can be matched to mental representations of expressions that have been encountered and labeled in the past. For example, for most people, downturned lips on a face have been, throughout their lives, repeatedly associated with the label "sad" or with behavioral indicators of sadness, such as crying. Face masks occlude some of the visual information used in this matching process. Second, emotion recognition can also rely on proprioceptive feedback from the perceiver's face; the feelings of mimicking the expression on someone else's face can provide essential input into the process of interpreting the expression (13). Because masks reduce visual information conveyed by the face, they can disrupt the production of corresponding facial mimicry in a perceiver. Finally, people rely on contextual information to interpret emotion expressions (14). Face masks, because they make expressions more ambiguous, may increase the use of pre-existing stereotypes and

expectations about emotions that fit the context, which may or may not result in an accurate reading of the expression (15).

The results of several studies provide indirect support for the hypothesis that face masks compromise the accuracy of emotion processing. Rychlowska and colleagues (16) presented adult participants with static images of infants expressing smiles, anger, and sadness. In addition to images of fully visible expressions, in some images the expressive infants were also sucking a pacifier, and in others, the infant's mouth was occluded by a white square to control for influences of participants' attitudes towards pacifiers. As participants examined the infant faces, their own facial mimicry was measured with methods of electromyography (EMG). Participants also rated the degree to which the faces expressed the target emotion, where the target emotion refers to the emotion putatively communicated by the specific expression. Facial mimicry and ratings of happiness were both lower when smile expressions were occluded by a pacifier and white square compared to when expressions were visible. In addition, ratings of sadness were lower when sad expressions were occluded. Participants in a study by Fischer and colleagues (17) saw videos of faces expressing smiles that were fully visible or occluded by a niqab, burqa, or a neutral occlusion covering (used to control for attitudes toward niqabs) and rated occluded smiles as showing less positive emotion than fully visible ones. And in Kret and de Gelder (18), participants recognized happiness and sadness in static images of faces with lower accuracy when the faces were covered by a niqab and burqa compared to fully visible.

Any adverse effect of information occlusion caused by mask-wearing may depend upon the degree to which information from a specific emotion expression—its signal—is largely conveyed on the lower or upper part of the face (19, 20). One method for describing the facial muscle actions that comprise emotion expressions is the Facial Action Coding System (FACS; 21). In this system, expressions of happiness (also termed reward smiles in the present report) are comprised of the lip corner puller (called action unit [AU] 12) and the cheek raiser, which causes crow's feet (AU 6). The disgust expression is composed of the nose wrinkler (AU 9), the lip corner depressor (AU 15), and the lower lip depressor (AU 16). In both expressions a large portion of their signal is thus located in the lower part of the face. In contrast, the anger expression is composed of the actions of three muscles on the upper part of the face (AUs 4, 5, and 7, brow lowerer, upper eye lid raiser, eye lid tightener, respectively) and one muscle on the lower part of the face, the lip tightener (AU 23). Surprise is also composed of three actions in the upper face (AUs 1, 2, and 5; inner brow raiser, outer brow raiser, upper eyelid raiser) and one action, jaw drop (AU 26), in the lower face.

The present Study 1 examined the four expressions just described (happiness, disgust, anger, and surprise) in order to evaluate the consequences for emotion perception of partly covering expressions that have either more upper-face versus lower-face signal. Other relevant findings bolster an interest in this comparison: Eye-tracking studies indicate that perceivers allocate more visual attention to the mouth when examining smiles and more attention to the brow when examining expressions of anger (22). And several studies reported no differences in the accuracy of the recognition of anger in

lower-face-covered versus fully visible faces (17-18), suggesting that a face mask may have less impact on the perception of facial expressions containing more of their signal in the upper compared to lower part of the face.

The reasoning thus far suggests that masks reduce the amount of a target emotion perceived for some, if not all, facial expressions; a smile looks less happy and a disgust expression looks less disgusted. However, there is also reason to expect that occluding parts of the face can increase the perception of other, non-target emotions as well. For example, in the study by Fischer and colleagues (17), perceivers of faces covered by a niqab or a black rectangle saw both smiles and expressions of shame as conveying more other negative emotions compared to fully visible faces. Relatedly, in a study by Maringer and colleagues (15), when participants' mimicry of another person's smile was inhibited, they were more likely to interpret the smile in terms of experimenter-provided contextual information. Use of the contextual information led to less accuracy in perceiving the genuineness of the smile.

A recent study investigated the recognition of facial expressions specifically covered by face masks (23). In that study, faces expressing happiness, sadness, anger, and disgust emotions covered with masks were misclassified as neutral or as conveying alternative emotional states more often than fully visible faces expressing the same emotions. This difference was not observed for expressions of fear or neutral emotion. While such findings are suggestive, like all of the other research on this general topic except one (17), the research employed static photographs as facial expression stimuli. However, it has been repeatedly demonstrated that much of the information from an

emotion expression is conveyed through its dynamic properties, that is, the timing of the contraction of participating muscles (i.e., facial motion; 24-26). The present two studies therefore employed dynamic facial expression videos rather than static images.

In Study 1 we investigated the perception of expressions of happiness, disgust, anger, and surprise that were fully visible, covered by one of three types of mask (N95, surgical, or cloth), or covered by a white rectangle that controlled for attitudes about mask wearing. In Study 2, we investigated the perception of different types of smiles, including reward, affiliation, and dominance smiles as described by Martin and colleagues (27, and see below). Because the use of a mask to protect oneself from the spread of COVID-19 has become politicized in the United States (28) we also examined the possible moderating role of political attitudes in any effect of masks on the perception of dynamic facial expressions in both studies. The moderating role of gender of the participant-perceiver was also examined since a recent meta-analysis confirmed that women are on average more accurate than men in recognizing facial expressions (29).

Results

Study 1: Effects of Masks on Perceiving Happiness, Disgust, Anger, and Surprise

In Study 1, 162 workers on Mechanical Turk (MTurk; Amazon's on-demand micro-task platform) viewed 168 videos of 14 different actors displaying happiness, disgust, anger, and surprise (factor "expression"). The actors' faces displayed neutral emotion at the beginning of the videos and then changed to express a particular emotion. On half of the trials, the face was fully visible, whereas on the remaining trials, the face was partially masked (factor "face presentation," see Figure 1). The face covering was

either a N95 mask, a blue surgical mask, a black cloth mask or a white rectangle (factor "mask type"). Mask type varied between subjects such that participants only saw one type of mask or the white rectangle throughout the study (final *N*'s were approximately 40 per mask type condition).

The four emotion expressions were seen an equal number of times on visible and masked trials. To reduce the possibility of comparing the same face in its visible versus masked presentation, no actor was shown expressing a given emotion on both types of face presentation. Expression videos were randomly presented four times, with participants asked to rate the extent to which the actor was expressing each emotion: once for happiness, once for disgust, once for anger and once for surprise. Thus, for every emotion expression on both fully visible and masked faces, we acquired ratings of the target emotion as well as the three non-target emotions (factor "rating scale").

Analyses revealed the predicted 2-way interaction between face presentation and rating scale, $F(1, 158) = 277.52$, $p < .001$, , $\eta_p^2 = .637$. Specific tests reported in Figure 2 indicate that, as expected, for all expressions, the target emotion was perceived as less present in masked versus visible faces. That is, happy, disgust, angry, and surprised expressions were perceived as less happy, disgusted, angry, and surprised, respectively, when masked compared to fully visible. Participants also perceived more of the non-target emotions in the masked faces in almost all cases as reported in the caption.

The perception of facial expressions occluded by masks varied by whether the expression prototypically carries more of its signal on the upper versus lower part of the face: There was a significant 2-way interaction between face presentation (visible,

189 masked) and facial action predominance (upper, lower face), $F(1, 158) = 7.17$, $p = .008$,
190 $\eta_p^2 = .043$, indicating that perceiving the target emotion in happy and disgust expressions
191 (with more signal in the lower part of the face) was compromised to a greater degree than
192 perceiving the target emotion in angry and surprised expressions (with more signal in the
193 upper part of the face).

194 Political attitudes did not uniformly moderate any of the findings, nor were they
195 moderated by gender of participant (see *S*1 Appendix, Appendix 1). Further statistical
196 analyses for study 1 are also described in *S*1 Appendix, Appendix 1).

197 **Study 2: Effects of Masks on Perceiving Reward, Affiliation, and Dominance Smiles**

198 The first study examined prototypical expressions of some of the so-called basic
199 emotions on masked versus visible faces, but many if not most expressions seen "in the
200 wild" are more nuanced. Imagine stopping to pick up after your dog on a sidewalk of a
201 bustling urban center. A person wearing a face mask passes you, makes eye contact, and
202 appears to express something. What is it? The person seems to be smiling but are they
203 smiling with disdain or gratitude? Are they commiserating because they are also a dog-
204 owner? Your classification of the smile will determine your response.

205 Smile expressions typically involve the activation of the muscle that causes the
206 corners of the lips to rise (i.e., AU 12 in the FACS), but there is variability in the degree
207 to which other actions are present and even the extent to which a participating muscle is
208 activated bilaterally. In fact, recent research supports the existence of more than one type
209 of smile, and while all types are honest social signals that have predictable effects on a

perceiver's physiology and behavior (e.g., 27, 30), they do not all communicate happiness. A social-functional account of the apparent heterogeneity of human smiles holds that different forms of smiles are deployed to accomplish distinct social tasks (27, 31): Reward smiles reinforce desired behavior in the self and others (i.e., they shape behavior), affiliation smiles communicate that the smiler is not a threat and is open to safe interaction (i.e., they invite affiliation), and dominance smiles are used to convey criticism and social status (i.e., they are used to negotiate social hierarchies). Recent studies have provided quantitative descriptions of the forms of these three social-functional smiles, which are shown in Figure 3 (e.g., 9).

The reward smile, which most people view as expressing happy feelings (and was employed in Study 1), is symmetrical and usually involves open lips, whereas the dominance smile is viewed as expressing far less happiness, is quite asymmetrical, and sometimes contains facial actions seen in contempt, including the nose wrinkler (AU 9) and the lip raiser (AU 10). English language speakers use the terms "smirk" or "smug smile" to describe this combination of features. The affiliation smile contains unique actions involving the dimpler (AU 14) and the lip presser (AU 24), which pull the upper lip across the teeth making for an expression that communicates appeasement and approachability. Returning to the previous example, a passerby could conceivably communicate reassurance or disdain as they observe you picking up after your dog in a dense urban area. Or they might even reward you for fulfilling what many consider a civic duty. But the morphological distinction among the smiles is largely evident on the

lower part of the face. So, detecting the meaning of a particular smile could be difficult when the person is wearing a mask.

In Study 2, participants saw videos of reward, affiliation, and dominance smiles in both fully visible and masked presentation. Because the major findings from Study 1 did not interact with mask type, only the N95 mask was used in this study. Participants rated all smiles in terms of the extent to which each conveyed positive feelings, reassurance, and superiority, which we selected to serve as labels for the signals communicated by reward, affiliation, and dominance smiles, respectively. Note that while we used labels derived from our scientific taxonomy of the smile, these labels might not be used by lay people. While the lay person has shared knowledge about expressions of the so-called basic emotions and their labels.

We started by confirming that smiles of reward, affiliation, and dominance, when fully visible, were perceived as communicating the target signals we had labeled as positive feelings (reward smiles), reassurance (affiliation smiles) and superiority (dominance smiles) see figure 4. Reward smiles were seen as signaling significantly more positive feelings (M = 72.5, SE = 1.99) than reassurance and superiority (M = 59.1, SE = 2.43), $t(59) = 5.25$, $p < .001$, d = .68.). Dominance smiles also signaled more superiority (M = 64.2, SE = 2.33) than positive feelings and reassurance (M = 58.2, SE = 2.28), $t(59) = 3.43$, $p = .001$, d = .44. However, in this sample, affiliation smiles did not signal significantly more reassurance than positive feelings and superiority ($t(59) = .35$, $p = .73$, d = .05).

The interaction between face presentation (visible, masked), smile type (reward, affiliation, dominance), and rating scale (target, non-target), $F(2, 118) = 4.79$, $p = .01$, $\eta_p^2 = .075$, was significant. As tests reported in the caption indicate, we found support for the hypothesis according to which masks impair perception of the target signal in all smile types. However, the non-target signals were not perceived more in masked versus fully visible faces.

These findings were not moderated by political attitudes or gender of the participant (see *S*1 Appendix, Appendix 2). Further statistical analyses for study 2 are also described in *S*1 Appendix, Appendix 2).

Discussion

If the eyes are the window to the soul, then masking faces during a pandemic should have no measurable consequences for the essential ability to perceive emotion in facial expressions accurately. But informal testimony suggests that the eyes alone are not enough: Individuals in service jobs regularly report that there have been frequent miscommunications about desires and concerns of customers due to disruptive effects of masks since the COVID-19 pandemic started (32). The present findings lend empirical support to these reports.

In Study 1, we found that masked happy, disgust, anger and surprise expressions were perceived as conveying significantly less happiness, disgust, anger, and surprise, respectively, than fully visible faces. The same expressions were also perceived as containing more of each of the other emotions. Findings for surprise varied from this

pattern in one way such that masks obscured the perception of the amount of positive emotion (rated as happiness) conveyed by the surprise expression.

As expected, the effects of masks on the perception of emotion were larger for expressions that contain descriptively more signal from facial muscle contractions on the lower compared to upper part of the face. That is, much of the communicative signal from happy and disgust expressions is present in the contraction of the muscles on the part of the face specifically covered by protective masks used during a pandemic. The extraction of information was somewhat less compromised for the expressions of anger and surprise, which involve more signal on the upper face.

In Study 2, the interpretation of dynamic smiles of reward, affiliation, and dominance that had been validated in previous work (30, 33) was also compromised when the smiles were covered by face masks. This was observed in particular for the smiles of reward and dominance. When covered by masks, reward smiles were perceived as signaling less positive feeling and dominance smiles were perceived as signaling less superiority. Ratings of affiliation smiles as specifically communicating reassurance (the label we used for the signaling of non-threat) were only marginally lower in masked compared to visible conditions.

Previous research has found that affiliation smiles have their intended effects in social interaction (e.g., increasing trust) and are mentally represented as possessing a morphology that is distinct from smiles of reward and dominance (12). Since the time that we selected the term “reassuring” to probe the perception of affiliation smiles for use in this study, other research in our laboratory found that the lay term that is most likely to be used for this smile is not “reassuring” but “fake” (30). This may be due to the fact that

except for “smirks” or “smug smiles” (i.e., dominance smiles in our terminology), which by definition do not signal that the smiler is feeling happiness, there is strong consensus in folk theory that “true” smiles always convey happiness. Thus, even though affiliation smiles may serve the function of communicating non-threat, they may be called “fake” colloquially because they are not, nor are they intended to be, signals of happiness. In future research, the impact of masked emotional expressions on subsequent social behavior and physiological responses, would provide a stronger test of the hypothesis that the perception of emotion in facial expression is compromised by face masks (cf. 33).

Future Directions

During the COVID-19 pandemic, people in all countries of the world have received recommendations for positive health behaviors, and the wearing of face masks is one such recommendation. This begs the question whether the perception of emotion expressions and facial signals of other internal states is hindered by mask wearing across cultures. Recent research on culture and emotion suggests that any detrimental effects of mask wearing are likely not uniform across culture.

Specifically, there are differences in how much emphasis cultures place on the explicit facial display of internal states of emotion (34). Rychlowska and colleagues (35) reported that people in countries of the world with ancestrally diverse populations (i.e., those in which historical migration patterns have produced a society composed of people from many different countries) tend to encourage the overt display of emotion on the face when emotion is felt internally. In contrast, people in less ancestrally diverse countries tend to encourage the suppression of explicit displays of emotion. The difference may in part be due to the fact that in places of high ancestral diversity there is relatively low

consensus about which emotions are experienced in which contexts (36, 37). Facial expressions may thus provide information that context does not (38). This reasoning suggests that there will be cultural differences in the effects of mask wearing such that masks are more detrimental to the processing of facial expression in societies of high compared to low ancestral diversity. Assessment of such differences will necessitate the study of facial expression in context rather than in isolation as in the present studies.

Even within culture there are likely to be changes in any effects of mask wearing over the period of a pandemic. And characteristics of both perceivers and mask wearers could plausibly contribute to these changes. Over time, perceivers may come to make more eye contact with mask wearers. Eye contact can trigger a more accurate simulation of the perceived expression and its corresponding state in the perceiver for use in interpreting the emotion signal (13). Mask wearers may begin to intentionally and ultimately automatically increase signals to their underlying emotions in the uncovered (upper) versus covered (lower) parts of their faces. Mask wearers may also begin to increase the expression of their emotions in modalities that are not occluded by masks such as the voice (39). And they may begin to use conventional gestures to complete or augment emotion signals from other expressive modalities (40). Given the decreased perception of happiness in a mask-covered smile observed in the present research, increasing other signals of positive emotion will be essential for everyday life.

342 **Methods**

343 **Study 1**

344 *Participants*

345 A total of 252 MTurk workers were recruited to participate in a "survey about
346 facial expressions." Those with lower than a 95% HITT rate were excluded. Of the total,
347 162 MTurk workers ranging in age from 20 to 73 (M = 36.46, SD = 10.85) completed the
348 study, passed the attention checks, and were included in the analyses. The final sample
349 was 55% male and was composed of individuals of whom 71.6% were White, 19.7%
350 African American, 5.5% Asian, and 3% Native American, Native Alaskan or Other.
351 Participants received $5 in compensation for completing the survey, which took them on
352 average 40 minutes.

353 **Materials**

354 *Masks*

355 We collected royalty free images of masks through an online image search. Three
356 masks were chosen to represent those most commonly worn during the COVID-19
357 pandemic including the N95, a blue surgical, and a black cloth mask. We created the
358 white rectangle using Microsoft 3D Paint and included it as a neutral facial occlusion to
359 control for attitudes toward mask wearing.

360 *Emotion Expression Videos*

361 Expression videos were selected from a large database of short, 1 to 3 second,
362 pre-recorded facial expression videos (12). The final stimulus set included videos of 14
363 actors (3 black females, 4 white females, 4 black males, 3 white males) expressing
364 smiles, anger, disgust, and surprise (42 total videos). Note that not all actors expressed

every one of the four emotion expressions. As discussed above, we used the expressions of anger and surprise because in their prototypic form they involve more facial actions in the upper part of the face, and happiness and disgust because they involve more facial action in the lower part of the face. While the videos have previously been normed, FACS coding of them was not performed for the present study. The fully visible conditions of the study served as a manipulation check on the level of target emotion communicated by each expression for the present samples.

Dynamic Emotion Expression Stimuli

Video stimuli were created using Davinci Resolve 16, a video editing application. We selected a single point on each actor's face and used point-tracking to track actor's movements during the expressions. The location of the point tracking varied due to differences in individual face morphology, and luminance and contrast of the video. The three masks and white rectangle were overlayed on each expression video (42), which yielded, together with the unmasked videos, 210 unique dynamic expression stimuli. The background of the masks was removed, and the masks and white rectangle were sized to fit the actors face. The white rectangle was sized to conceal the approximate amount of the actor's face as the three masks. The top, middle of each mask and the white rectangle were placed on the bridge of the nose, so they extended approximately 1-inch below the actor's eyes (Figure 5). The masks and white rectangle overlay were then matched to the movement of the actor which ensured that the mask and white rectangle occluded the actor's face over the duration of the video to the same degree (Video stimuli can be found at https://osf.io/rbhxd/).

Survey

Data were collected via a survey hosted on the Qualtrics online survey platform. Video stimuli of facial expressions (happy, disgust, anger, surprise) for each actor were crossed with rating scale (happiness, disgust, anger surprise) and face condition (mask or visible) resulting in 840 dynamic expression stimuli and rating scale pairings. The expression-rating scale pairings were first divided into four surveys according to mask type (N95, surgical, cloth, white rectangle), with all four surveys including visible face videos. Therefore, each survey contained 332 pairings which we further divided into two versions containing half of the video stimuli resulting in 168 trials per survey. The surveys were constructed such that participants did not see a given actor with and without a mask. The two versions were equated for the race (African American, White) and gender (male, female) of the actors and included four attention check questions. Videos of actors that expressed multiple expressions were kept together so participants did not see the same actor with and without a mask. Participants rated the emotion expressed in each video by responding to the prompt, "How much (happiness/disgust/anger/surprise) is this person expressing?", on a 100-point scale (0 = none to 100 = a great deal).

Demographic questions were included at the end of the survey. Participants reported their age, gender, and race, along with their political ideology on a 7-point scale (1 = very conservative to, 7 = very liberal), and geographical location. Geographical location was assessed on two dimensions, rural versus urban, and state and city of residence. The researchers also included two validity checks at the end of the survey, "Did you watch each video before answering the question?" and "Did you experience any problems with the videos or survey?"

Study 2

Participants

A total of 93 MTurk workers were recruited to participate in a "survey about facial expressions." Those with lower than a 95% HITT rate were excluded. Of the total, 60 MTurk workers ranging in age from 23 to 68 (M = 35.25, SD = 9.01) completed the study, passed the attention checks, and were included in the analysis. The final sample was 60% male, of whom 68.3% were White, 28.3% African American, and 3.3% Asian or Other. Participants received $4 in compensation for completing the study that took on average 32 minutes.

Materials

Dynamic Expression Stimuli

Smile expression videos were selected from the same database of pre-recorded facial expression videos as Study 1 (30, 12). The stimulus set included videos of 14 actors (3 black females. 4 white females, 4 black males, 3 white males) expressing reward, affiliation, and dominance smiles (Figure 6) totaling 34 stimuli. Note that not every actor expressed all three smiles. Because there were no important interactions with mask type found in Study 1, only the N95 mask was applied to the smile videos, again with DaVinci Resolve 16 and following the same steps outlined in Study 1.

Video stimuli of smile expressions were crossed with rating scale (positive feeling, reassurance, superiority) and face condition (mask or visible) resulting in 204 dynamic expression stimuli and rating scale pairings.

Survey

Data were collected via a survey hosted again on the Qualtrics online survey platform. Expression stimuli were divided into two versions of the survey to ensure participants did not see an actor expressing the same type of smile both fully visible and masked. Participants were randomly assigned to be in one of the two versions of the survey and stimuli were randomly presented within each version. The two versions were equated for race and gender of actor and included four attention check questions. Each version of the survey contained 102 dynamic expression stimuli which participants rated on the same 100-point scale, "How much (positive feeling/reassurance/superiority) is this person expressing?" Study 2 included three attention check questions and participants completed the same demographics questionnaire and validity check questions as Study 1.

Acknowledgments

The authors thank Ann Shaffer for her expert editing and to Sari Judge for her communication expertise. Markus Brauer provided statistical consulting and Carolin Showers gave detailed feedback on a version of the manuscript. Dasha A. Yermol received a University of Wisconsin-Madison Hilldale Fellowship for her efforts on this project.

Author Contributions:

A.T.L., D.A.Y., F.Z., C.A.T., and P.M.N designed research; A.T.L. and D.A.Y. performed research; F.Z. and C.A.T. analyzed data; and A.T.L., F.Z., C.A.T., and P.M.N. wrote the paper.

Competing Interest Statement:

The authors declare no conflict of interest.

Data availability:

The materials and data from this research are publicly available at https://doi.org/10.17605/OSF.IO/RBHXD.

Code availability

The data analysis code that supports these results is publicly available at https://doi.org/10.17605/OSF.IO/RBHXD.

References

1. Brooks, J. T., Butler, J. C., Redfield, R. R. Time for universal masking and prevention of transmission of SARS-CoV-2. *JAMA*. Published online July 14, 2020. https://doi.org/10.1001/jama.2020.13107.
2. World Health Organization, Coronavirus disease (COVID-19) advice for the public: When and how to use Masks. Available at https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public/when-and-how-to-use-masks. Accessed October 21, 2020.
3. Cattaneo, L., Pavesi, G., The facial motor system. *Neurosci Biobehav Rev*, 38, 135-159. https://doi.org/10.1016/j.neubiorev.2013.11.002.
4. Crivelli, C., Fridlund, A. J. Facial displays are tools for social influence. *Trends Cogn Sci,* 22(5), 388-399 (2014). https://doi.org/10.1016/j.tics.2018.02.006.
5. Jack, R. E., Schyns, P.G. The human face as a dynamic tool for social communication. *Curr Bio*, 25(14), R621-R634 (2015). https://doi.org/10.1016/j.cub.2015.05.052.
6. Kret, M. E., Prochazkova, E., Sterck, E.H., Clay, Z. Emotional expressions in human and non-human great apes. *Neurosci Biobehav Rev* (2020). https://doi.org/10.1016/j.neubiorev.2020.01.027.
7. Hastings, M. E., Tangney, J. P., Stuewig, J. Psychopathy and identification of facial expressions of emotion. *Pers Individ Dif*, 44(7), 1474-1483 (2008). https://doi.org/10.1016/j.paid.2008.01.004.
8. Marsh, A. A., Blair, R.J.R. Deficits in facial affect recognition among antisocial populations: a meta-analysis. *Neurosci Biobehav Rev*, 32(3), 454-465 (2008). https://doi.org/10.1016/j.neubiorev.2007.08.003.
9. Niedenthal, P. M., Brauer, M. Social functionality of human emotions. In S.T. Fiske (Ed.), *Annu Rev Psychol*, 62, 259-285 (2011). https://doi.org/10.1146/annurev.psych.121208.131605.
10. Baron-Cohen, S., Wheelwright, S., Jolliffe, T. Is there a "Language of the Eyes"? Evidence from normal adults, and adults with autism or Asperger syndrome. *Vis Cogn*, 4, 311–331 (1997). https://doi.org/10.1080/713756761.
11. Keltner, D., Ekman, P., Gonzaga, G. C., Beer, J. Facial expression of emotion. In Davidson, R. J., Scherer, K. R., & Goldsmith, H. H. (Eds.), *Series in affective science. Handbook of affective sciences* (p. 415–432). Oxford University Press (2003). https://doi.org/10.1007/s10919-019-00293-3.
12. Rychlowska, M., Jack, R. E., Garrod, O., Schyns, P. G., Martin, J. D., Niedenthal, P.M. Functional Smiles: Tools for Love, Sympathy, and War. *Psychol Sci.,* 28(9), 1259–1270 (2017). https://doi.org/10.1177/0956797617706082.
13. Wood, A., Rychlowska, M., Korb, S., Niedenthal, P.M. Fashioning the face: sensorimotor simulation contributes to facial expression recognition. *Trends in Cog Sci*, 20(3), 227-240 (2016). https://doi.org/10.1016/j.tics.2015.12.010.
14. Hassin, R. R., Aviezer, H., Bentin, S. Inherently ambiguous: Facial expressions of emotions, in context. *Emotion Review*, 5(1), 60-65 (2013). https://doi.org/10.1177/1754073912451331.

15. Maringer, M., Krumhuber, E. G., Fischer, A. H., Niedenthal, P.M. Beyond smile dynamics: Mimicry and beliefs in judgments of smiles. *Emotion*, 11(1), 181–187 (2011). https://doi.org/10.1037/a0022596.
16. Rychlowska, M. et al. Pacifiers disrupt perceivers' emotional responses to infants' emotions. Basic and Applied Social Psychology, 36(4), 299-308 (2014). https://doi.org/10.1080/01973533.2014.915217.
17. Fischer, A. H., Gillebaart, M., Rotteveel, M., Becker, D. Veiled Emotions. *Soc Psychol Personal Sci*, 3(3), 266-273 (2012). https://doi.org/10.1177/1948550611418534.
18. Kret, M. E., de Gelder, B. Islamic headdress influences how emotion is recognized from the eyes. Front. *Psychol*. 3:110 (2012). https://doi.org/10.3389/fpsyg.2012.00110.
19. Calvo, M. G., Nummenmaa, L. Detection of emotional faces: Salient physical features guide effective visual search. *J Exp Psychol*: General, 137, 471–494 (2008). https://doi.org/10.1037/a0012771.
20. Smith, M. L., Cottrell, G., Gosselin, F., Schyns, P. G. Transmitting and decoding facial expressions of emotions. *Psychol Sci*, 16, 184–189 (2005). https://doi.org/10.1111/j.0956-7976.2005.00801.x.
21. Ekman, P., Friesen, W. V., Hagar, J. C. Facial Action Coding System (pp. 15–464). Salt Lake City, America: Research Nexus division of Network Information Research Corporation (2002).
22. Eisenbarth, H., Alpers, G.W. Happy mouth and sad eyes: scanning emotional facial expressions. *Emotion*, 11(4), 860 (2011). https://doi.org/10.1037/a0022758.
23. Carbon, C. C. The Psychology of Wearing Face Masks in Times of the COVID-19 Pandemic (April, 2020). https://doi.org/10.2139/ssrn.3584834.
24. Ambadar, Z., Schooler, J. W., Cohn, J. F. Deciphering the enigmatic face: The importance of facial dynamics in interpreting subtle facial expressions. *Psychol Sci*, 16(5), 403-410 (2005). https://doi.org/10.1111/j.0956-7976.2005.01548.x.
25. Back, E., Jordan, T. R., Thomas, S. M. The recognition of mental states from dynamic and static facial expressions. *Vis cogn*, 17(8), 1271-1286 (2009). https://doi.org/10.1080/13506280802479998.
26. Kamachi, M. et al., Dynamic properties influence the perception of facial expressions. Perception, 42(11), 1266-1278 (2013). https://doi.org/10.1068/p3131.
27. Martin, J., Rychlowska, M., Wood, A., Niedenthal, P. M. Smiles as multipurpose social signals. *Trends in Cognitive Science*, 21(11), 864-877 (2017). https://doi.org/10.1016/j.tics.2017.08.007.
28. Pew Research Center, June, 2020. Republicans, Democrats Move Even Further Apart in Coronavirus Concerns. Available at: https://www.pewresearch.org/politics/2020/06/25/republicans-democrats-move-even-further-apart-in-coronavirus-concerns. Accessed November 13, 2020.
29. Thompson, A. E., Voyer, D. Sex differences in the ability to recognise non-verbal displays of emotion: A meta-analysis. Cognition and Emotion, 28(7), 1164-1195 (2014). https://doi.org/10.1080/02699931.2013.875889.

30. Martin, J.D. et al., Reward, Affiliation, and Dominance Smiles Are Associated with Distinct Mental Content. (2020). https://doi.org/10.31234/osf.io/tmbhv.
31. Niedenthal, P. M., Mermillod, M., Maringer, M., Hess, U. The Simulation of Smiles (SIMS) model: Embodied simulation and the meaning of facial expression. Target article for *Behavioral and Brain Sciences*, 33, 417–480 (2010).
32. Bhattarai, A.Cranky customers, masked smiles redefine workplace culture: 'Feels like we're strangers', (2020, September 23). Available at: https://www.washingtonpost.com/road-to-recovery/2020/09/23/masks-workplace-culture-pandemic. Accessed November 23, 2020.
33. Martin, J.D., Abercrombie, H. C., Gilboa-Schechtman, E., Niedenthal, P. M., Functionally distinct smiles elicit different physiological responses in an evaluative context. *Sci Rep*, 8(1), 3558 (2018). https://doi.org/10.1038/s41598-018-21536-1.
34. Matsumoto, D., Yoo, S. H., Fontaine, J. Mapping expressive differences around the world: The relationship between emotional display rules and individualism versus collectivism. *J Cross Cult Psychol*, 39(1), 55-74 (2008). https://doi.org/10.1177/0022022107311854.
35. Rychlowska, M. et al. Heterogeneity of long-history migration explains cultural differences in reports of emotional expressivity and the functions of smiles. *Proc Natl Acad Sci USA*, 112, E2429–E2436 (2015).
36. Gelfand, M. J. et al. Differences between tight and loose cultures: A 33-nation study. Science, 332, 1100- 1104 (2011). https://doi.org/10.1126/science.1197754.
37. Masuda, T. et al. Placing the face in context: cultural differences in the perception of facial emotion. *J Pers Soc Psychol*, 94(3), 365 (2008). https://doi.org/10.1037/0022-3514.94.3.365.
38. Niedenthal, P. M., Rychlowska, M., Zhao, F., Wood, A. Historical Migration Patterns Shape Contemporary Cultures of Emotion. *Perspectives on Psychological Science*, 14(4), 560–573 (2019). https://doi.org/10.1177/1745691619849591.
39. Laukka, P. Categorical perception of vocal emotion expressions. *Emotion*, 5(3), 277–295 (2005). https://doi.org/10.1037/1528-3542.5.3.277.
40. Wood, A., Martin, J. D., Alibali, M. W., Niedenthal, P. M. A sad thumbs up: incongruent gestures and disrupted sensorimotor activity both slow processing of facial expressions. *Cognition and Emotion*, 33(6), 1196-1209 (2019). https://doi.org/10.1080/02699931.2018.1545634.

Figures and Tables

Figure 1. Dynamic expression stimuli for study 1. Top panel shows still images taken from of faces dynamically expressing, from left to right, happiness, disgust, anger, and surprise. The lower panels show images from the same faces covered by a surgical mask, N95 mask, and black cloth mask.

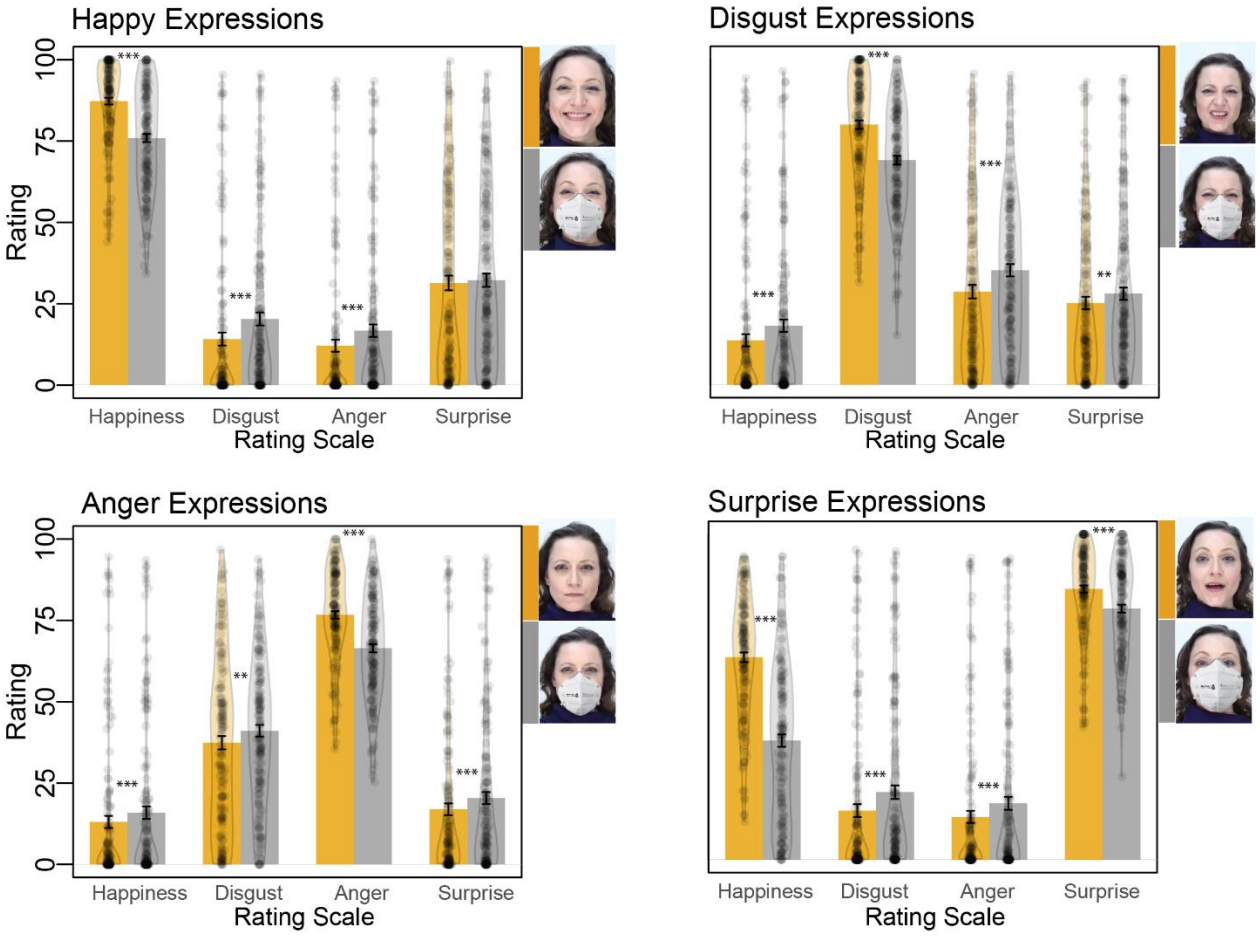

Figure 2. Emotion ratings of visible and masked faces. The graphs illustrate levels of emotion perceived in videos of visible and masked faces dynamically expressing happiness, anger, disgust, and surprise. Separate t-tests comparing perception of emotion in each expression indicate that participants perceived significantly less of the target emotion (*ps* < .001), and significantly more of most non-target emotions (*ps* < .008) in masked compared to visible faces. Two exceptions of note were that surprise was not perceived as more present in masked happy expressions ($p = .43$) and happiness was perceived as significantly less present in masked surprise expressions ($p < .001$). *p<.05, **p<.01, ***p<.001.

Figure 3. Examples of smile stimuli. Reward (left), affiliation (center), and dominance (right).

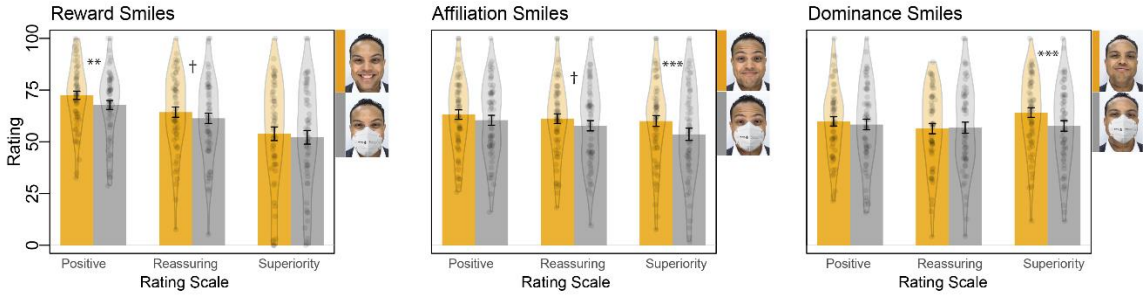

Figure 4. Social signals of masked and visible smiles. The graphs illustrate levels of social signals communicated in videos of visible and masked faces expressing reward, affiliation, and dominance smiles. For reward smiles, masks reduced both the target signal (positive feeling; $p = .003$) and non-target signals ($p = .046$), however, a marginally significant ($p = .072$) between face presentation and rating scale interaction indicated that the effect was stronger for the target signal ratings than non-target signal ratings. For affiliation smiles, masks impaired perceptions of both the target (reassurance; $p = .06$) and non-target ratings ($p = .002$), and the interaction was not significant ($p = .40$). For dominance smiles, masks impaired perception of the target signal (superiority; $p < .001$) but not of non-target ratings ($p = .67$). The interaction was significant ($p = .006$). †$p < .10$, *$p < .05$, **$p < .01$, ***$p < .001$

Figure 5. Mask location for dynamic emotion expression stimuli. The green line in the center of the image represents the tracked point of the actor's face and movement throughout the video.

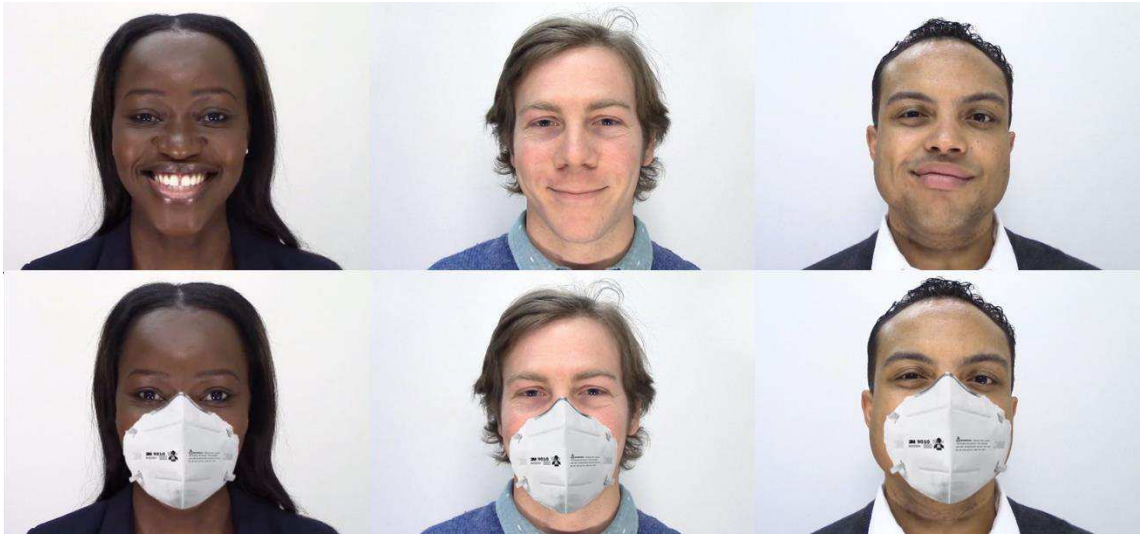

Figure 6. Masked and visible dynamic smile stimuli. Top panel shows images taken from dynamic videos of, from left to right, reward, affiliation and dominance smiles. The lower panel show images from the same faces covered by the N95 mask.

Figures

Figure 1

Dynamic expression stimuli for study 1. Top panel shows still images taken from of faces dynamically expressing, from left to right, happiness, disgust, anger, and surprise. The lower panels show images from the same faces covered by a surgical mask, N95 mask, and black cloth mask.

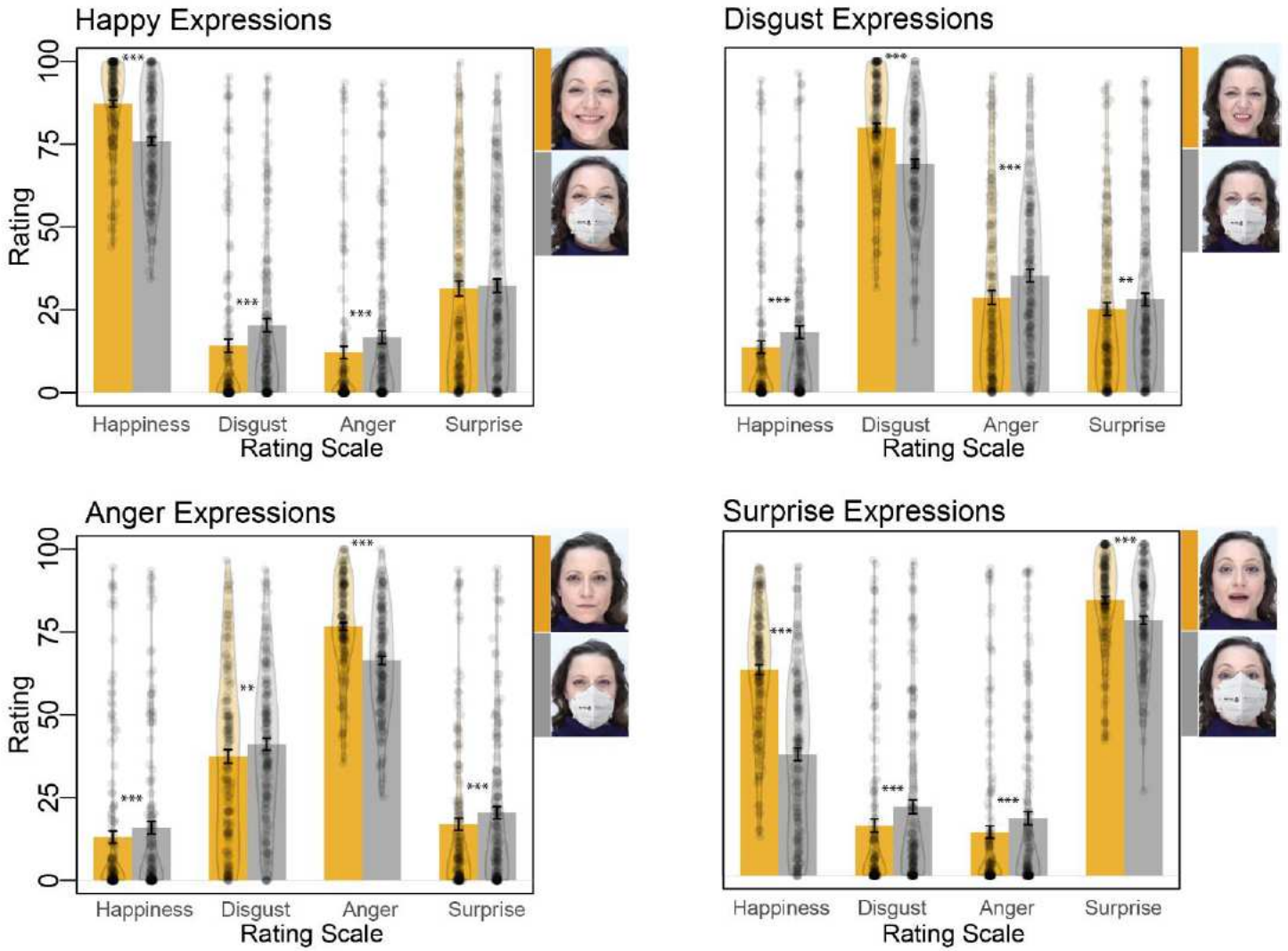

Figure 2

Emotion ratings of visible and masked faces. The graphs illustrate levels of emotion perceived in videos of visible and masked faces dynamically expressing happiness, anger, disgust, and surprise. Separate t-tests comparing perception of emotion in each expression indicate that participants perceived significantly less of the target emotion (ps < .001), and significantly more of most non-target emotions (ps < .008) in masked compared to visible faces. Two exceptions of note were that surprise was not perceived as more present in masked happy expressions (p = .43) and happiness was perceived as significantly less present in masked surprise expressions (p < .001). *p<.05, **p<.01, ***p<.001.

Figure 3

Examples of smile stimuli. Reward (left), affiliation (center), and dominance (right).

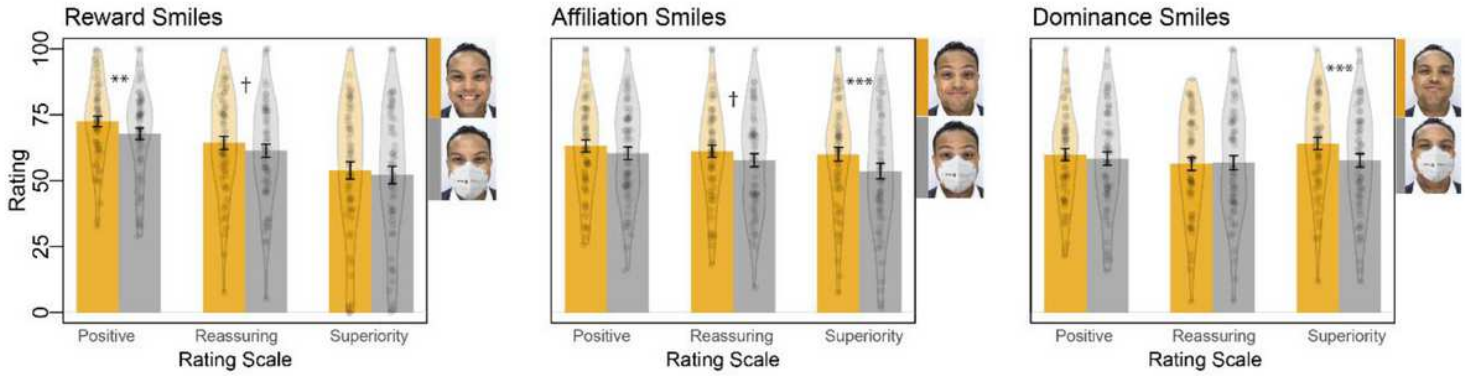

Figure 4

Social signals of masked and visible smiles. The graphs illustrate levels of social signals communicated in videos of visible and masked faces expressing reward, affiliation, and dominance smiles. For reward smiles, masks reduced both the target signal (positive feeling; $p = .003$) and non-target signals ($p = .046$), however, a marginally significant ($p = .072$) between face presentation and rating scale interaction indicated that the effect was stronger for the target signal ratings than non-target signal ratings. For affiliation smiles, masks impaired perceptions of both the target (reassurance; $p = .06$) and non-target ratings ($p = .002$), and the interaction was not significant ($p = .40$). For dominance smiles, masks impaired perception of the target signal (superiority; $p < .001$) but not of non-target ratings ($p = .67$). The interaction was significant ($p = .006$). †$p < .10$, *$p < .05$, **$p < .01$, ***$p < .001$

Figure 5

Mask location for dynamic emotion expression stimuli. The green line in the center of the image represents the tracked point of the actor's face and movement throughout the video.

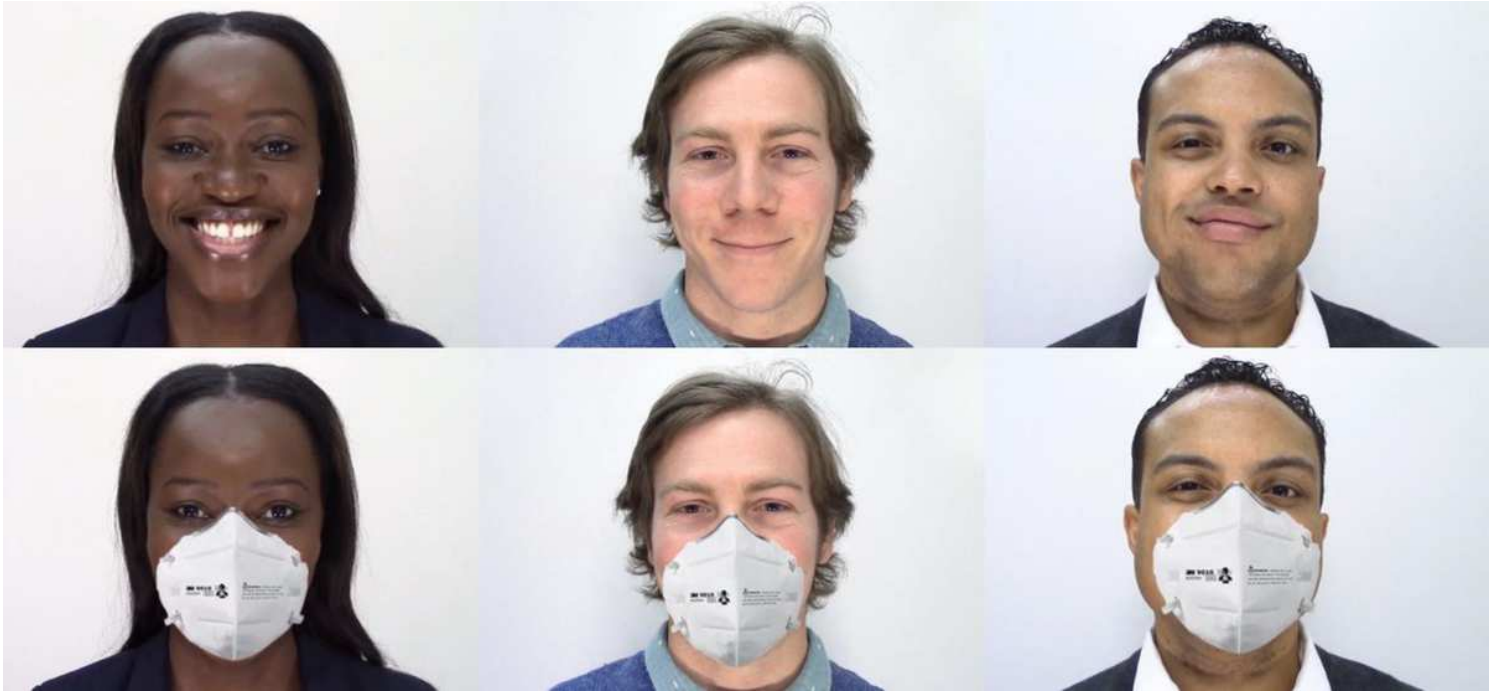

Figure 6

Masked and visible dynamic smile stimuli. Top panel shows images taken from dynamic videos of, from left to right, reward, affiliation and dominance smiles. The lower panel show images from the same faces covered by the N95 mask.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- MaskedFacesS1.docx