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BRIEF ARTICLE

(Un)mask yourself! Effects of face masks on facial mimicry and emotion perception during the COVID-19 pandemic

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ABSTRACT
Face masks have been said to impact face-to-face interaction negatively. Yet, there is limited evidence on the degree to which partial face occlusion is detrimental to empathic processes such as emotion perception and facial mimicry. To address this question, we conducted an online experiment (*N*=200, U.K. sample) that assessed subjective ratings and facial expressions (mimicry) in response to masked and unmasked faces. Perceivers were able to recognise happiness and sadness in dynamic emotion expressions independent of (surgical) face masks. However, perceived emotion intensity and interpersonal closeness were reduced for masked faces. Facial mimicry, the perceiver's imitation of the expresser's emotional display, was reduced or absent in response to happy but preserved for sad mask-covered expressions. For happy target expressions, the face-mimicry link was partially mediated by perceived emotion intensity, supporting the idea that mimicry is influenced by context effects. Thus, these findings suggest that whether face masks impede emotion communication depends on the emotion expressed and the emotion-communication aspect of interest. With unprecedented changes in nonverbal communication brought about by the COVID-19 pandemic, this research marks a first contribution to our understanding of facial mimicry as an important social regulator during these times.

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During the current COVID-19 pandemic, face masks have become ubiquitous. Since these masks cover parts of the face, they can be expected to impact on social cognition and interaction (see van Bavel et al., 2020). The present research assessed effects of face masks on facial mimicry and emotion perception.

Face masks and emotional mimicry

Specifically, masks cover the mouth region – an important source of emotional information (Boucher & Ekman, 1975). As such, emotion expressions in faces covered with surgical masks on blank backgrounds tend to be recognised less well than in uncovered faces among adults (Carbon, 2020; Grundmann et al., 2021) and children (Ruba & Pollak, 2020). Hence, we expect face masks to impede emotion perception in the observer.

Yet, emotion expressions are not only perceived but also responded to. One important (nonverbal) behaviour in response to observing emotion expressions is emotional mimicry, the spontaneous and largely unconscious imitation of an interaction partner's emotional display (Hess & Fischer, 2013). Emotional mimicry plays an important role in social rapport (Hess et al., 1999) and (affective) empathy (Drimalla et al., 2019), and predicts perceived social interaction quality (Mauersberger & Hess, 2019).

At first glance, masks should impede facial mimicry because they occlude major parts of the face. However, emotion expressions form a pattern across the face, and most include some information in the eye region, even if the mouth region may be more informative (Boucher & Ekman, 1975). For example, even though the most obvious sign of smiling, the drawing up of the corners of the mouth, is hidden

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behind a mask, other signs, namely the pushing up of the cheeks and the wrinkles around the eyes, which may accompany this movement, remain visible. In this vein, humans are generally able to deduce various mental states from information in the eye region alone (Baron-Cohen et al., 1997, Schmidtmann et al., 2020). Further, there is evidence that people can mimic an emotion expression facially even if they only see the body or hear the voice (i.e. cross-modal mimicry, Hawk et al., 2012). In fact, as long as people recognise the emotion shown, even if accuracy is overall reduced, they tend to mimic the expression even if it is only partially visible (Blaison et al., 2013).

Importantly, however, according to the emotional mimicry as social regulator perspective, emotional mimicry is both dependent on and facilitative for affiliation (Hess & Fischer, 2013, 2016; Mauersberger & Hess, 2019). Accumulating evidence documents the role of affiliation for emotional mimicry at least down to the age of three (Vacaru et al., 2019). We have used the term affiliative mimicry (Hess, 2021) for the mimicry of emotion expressions that signal affiliation, such as happiness and sadness (Knutson, 1996). By contrast, when an observer does not want to affiliate with an expresser, for example, because that person is perceived as behaving inappropriately in a given context, mimicry is reduced or absent (Kastendieck et al., 2020). Hence, whether mask-wearing signals appropriate or inappropriate behaviour to an observer should impact mimicry.

Face masks, face processing, and emotion perception

Pre-pandemic data suggest that face masks can have ambivalent social consequences. Surgical mask wearers were perceived as competent but unemotional, and their emotions as less intense than when similarly covered with scarfs or niqabs (Hareli et al., 2013). Moreover, medical doctors who wore professional masks during consultations were perceived by patients as less relationally empathic (Wong et al., 2013). More recently, peri-pandemic findings also show that masks have an effect on person perception. For example, surgical mask wearers were more likely to be perceived as ill but also as more trustworthy and socially adequate (Olivera-La Rosa et al., 2020). Thus, face masks, like those common in the pandemic, are likely to serve as social signals for person perception. In turn, the beliefs we hold about others influence how we perceive their emotions (e.g. Bijlstra et al., 2014). These findings point to a possible influence of stereotypical beliefs regarding masked faces, next to the obvious effect of obscuring the face. Moreover, in peri-pandemic mask studies, mask type (e.g. surgical, N95, community), and where the mask is worn (e.g. spatial context) may also matter. Although some studies have varied the former, the latter is typically not varied. In this study, we decided to keep mask type constant and vary the context in which the masked vs. unmasked faces were shown.

Thus, we chose the probably most prototypical mask at the time of the data collection: the surgical mask. Yet, since wearing a mask or failure to do so may have different social consequences in different spatial contexts, we studied the effects of masks in two different scenes. An outdoor scene (park), where mask-wearing was at the time of the data collection (August 2020) not enforced in the country where the data collection took place (i.e. U.K.), and an indoor scene (grocery store), where masks were obligatory at the time of the study. The sharing of indoor environments is the major risk for COVID-19 transmission (Qian et al., 2021). Aerosol research suggests that 99.9% of infections occur inside (Asbach et al., 2020). Hence, we speculated that the social consequences of a failure to wear a mask are more pronounced indoors.

Goal of the present study

The present study had the goal to assess (a) whether surgical masks have an impact on emotion perception, specifically, whether face masks reduce the emotion recognition (hit) rate, reduce the perceived intensity of the expression, and increase the bias, that is, the ratings on the distractor emotions, (b) whether face masks reduce interpersonal closeness, and (c) whether face masks reduce affiliative facial mimicry; (d) we further explored whether scene context moderates these relationships in that more incongruent combinations of emoter and scene (e.g. no mask in a store) would be more detrimental to the outcome variables. Moreover, we investigated whether the link between mask condition and facial mimicry was mediated by perceived emotion intensity, as the mimicry as social regulator perspective would suggest (Hess & Fischer, 2013), or whether, conversely, the link between mask condition and perceived emotion intensity was mediated by facial mimicry as embodiment accounts would suggest (e.g. Niedenthal et al., 2017). We also aimed to assess the impact of attitudes toward masks but were not able to do this due to a lack of variance in that variable in our sample.

Hypotheses

Hypothesis 1. The presence of face masks in target faces reduces emotion perception quality (H1a: reduced recognition rate, H1b: reduced perceived intensity, H1c: increased bias).

Hypothesis 2. The presence of face masks in target faces reduces perceived interpersonal closeness.

Hypothesis 3. The presence of face masks in target faces reduces facial mimicry.

Hypothesis 4. These dependent variables are particularly affected when face mask wearers are embedded into scenes where face mask use is less expected.

Hypothesis 5. Perceived emotion intensity mediates the relationship between face condition and facial mimicry.

Method

Power considerations

Effect sizes for mimicry effects found with electromyography in our laboratory tend to range from η_p^2=.15 to η_p^2=.3. From our perspective, there are currently no satisfactory a priori power analysis tools for linear mixed modelling for the design we used. Especially the a priori determination of important model parameters (e.g. intraclass correlation, first and second level standard deviations, random-slope variance) can be deemed problematic.

However, arguably, an ANOVA-oriented power analysis can be considered a lower bound for a power analysis for LMM. Therefore, based on the conservative effect size η_p^2=.15 and aiming for 95% power at alpha=.05, we conducted a power analysis with MorePower 6.0 (Campbell & Thompson, 2012) for an ANOVA-based analysis strategy. The analysis indicated that 76 participants are required for the current within-participant design. Yet, due to lack of prior peri-pandemic evidence, it is still problematic to estimate the size of the effect of obscuring the face with masks on mimicry, especially as we used a less sensitive measure of facial activity. Hence, we decided to double the sample size to at least 152 participants as it is preferable to have a larger than required sample than to end up with insufficient power.

Finally, as we filmed participants online using their webcams and then uploaded the videos for analysis, we anticipated a relatively high loss of data. We, therefore, decided to oversample by at least 25% to compensate for likely technical problems (e.g. faulty or slow internet connections, problematic browser settings, or poor camera resolution).

Participants

A total of 244 participants completed the online experiment and gave their consent via Prolific U.K. The final sample consisted of data from 200 participants (140 women) with a mean age of 32.9 (SD=12.68), who reported having seen the video stimuli (three were excluded as they did not) and for whom at least one video upload was successful (41 were excluded because none was uploaded). The sample was not intended to be geographically representative, nonetheless, participants came from a wide range of U.K. regions. Of the 4800 video stimuli across the remaining 200 participants, only 88 video uploads were not successful (1.8%). Participants received £2.75 on average for their participation, which is classified as *good* payment in Prolific. The mean task time was 12 min and 45 s (advertised as a 15-minute task).

Materials

Face video stimuli (3 female, 3 male actors) from the Amsterdam Dynamic Facial Expression Set (ADFES, van der Schalk et al., 2011) were selected, each showing a happy and a sad expression. The videos were edited using segmentation within an augmented reality software (Lens Studio by Snap Inc.), such that a surgical face mask (foreground; mask vs. no mask) and two different public scenes (background; park vs. store) were integrated for the respective experimental conditions. The mask was attached to the face using the face tracking function of Lens Studio to model a dynamic interplay of the face and mask, allowing the mask to move naturally with the moving face. For the scenes, photos from a park and a store in Berlin were added to the background (see Figure 1).

The videos had a length of 7.5 s and first showed a fixation cross (1.5 s), then the neutral face within the scene (M=1.01 s, Min=0.93 s, Max=1.13 s), the developing of the expression (M=1.89 s, Min=0.77 s, Max=3.3 s), and finally the apex expression (M=3.1 s, Min=1.63 s, Max=4.3 s). The final stimulus set consisted of 2 (actor

Figure 1. Examples of happy and sad expressers with and without masks in a park and a store. Note: Facial video stimuli were adapted, with permission, from the Amsterdam Dynamic Facial Expression Set (ADFES, van der Schalk et al., 2011) and dynamically embedded into static scenes. Depicted are frames at apex or peak of expressivity.

gender) × 3 (actors) × 2 (emotion expression) × (2 mask/no mask) × 2 (scene) = 48 different videos. To avoid fatigue, each participant saw only half the set (i.e. 24 videos) which were presented in random order. Videos were counterbalanced across participants.

Procedure

Participants were informed that they will see 24 short videos, that the task will take about 15 minutes, and that participation in the experiment is only possible if they have a webcam-enabled computer/laptop and agree to a webcam recording of their face during the experiment. Informed consent included standard details on compensation, confidentiality, and contact information as well as detailed information on (video) data storage and processing. Participants who agreed to participate were instructed to set up their webcam to allow recording, to arrange sufficient lighting, and to refrain from eating or covering their face during the experiment. Finally, participants provided socio-demographic information.

Participants then saw the video stimuli while their facial activity was recorded. Following each video, using 7-point scales, participants rated the targets' emotion expressions using an emotion profile (happiness, sadness, fear, anger, disgust, and surprise), and indicated how close they felt to the person shown using the Inclusion of Other in the Self-scale (IOS, Aron et al., 1992). Following the video task, participants were asked COVID-related questions, such as to what extent they "think it is reasonable to wear a mask in public in the context of the COVID-19 pandemic."[1]

On each page of the procedure, participants were given the opportunity to opt out and get their data discarded. Finally, participants were informed about the purpose of the experiment, thanked for their participation, and received the necessary code for payment.

Facial behaviour analysis

The uploaded videos were analysed using the open-source facial behaviour analysis toolkit OpenFace 2.0 (Baltrusaitis et al., 2018). OpenFace analyses facial activity in terms of facial action units as classified in the Facial Action Coding System (Ekman & Friesen, 1978). Frames with a detection confidence lower than 75% were excluded (Drimalla et al., 2020). The mean confidence across all used frames was 97% (SD=3%). Based on a visual check, OpenFace data from 30 participants had to be excluded as they showed insufficient adherence to task instructions (e.g. talking or eating during the task), used insufficient lighting, or obstructed their face.

Data preparation

Based on the OpenFace data, facial mimicry was assessed using facial action units AU4 (eyebrows drawn together), AU6 (wrinkles in the corner of the eyes), and AU12 (lip corners pulled up). Baseline-corrected, within-subject z-transformed scores were calculated to control for participants' general expressiveness. The fixation cross (1.5 s) before each stimulus served as a dynamic baseline. With these transformed scores, a positive pattern score was computed, as described by Hess et al. (2017) for facial EMG, which indicates the contrast between the average activity of zygomaticus major (or AU12 in OpenFace) and orbicularis oculi lateralis (AU6), minus the activity of corrugator supercilii (AU4). The converse contrast formed the negative pattern score. Frames of the uploaded videos were divided into segments corresponding to those of the stimulus material: neutral face, onset, and apex. Videos of example stimuli, a detailed R Markdown, a shorter table overview, and datasets can be found at Open Science Framework (OSF), https://osf.io/n2btd/ or doi:10.17605/OSF.IO/N2BTD (Study 2); datasets also at Harvard Dataverse, doi:10.7910/DVN/I1LSFY.

Results

Emotion perception

Quite surprisingly, participants were 99.8% (no mask) and 99.7% (mask) accurate when decoding the expressions. Thus, hypothesis 1a [emotion recognition (hit) rate] was not supported. Yet, only happy and sad expressions were shown in the design. Given the low task difficulty, this very high emotion recognition rate, located at the ceiling, could have been the result of learning a somewhat easy task. However, in accordance with hypothesis 1b, mask-wearing had an effect on perceived emotion intensity. An LMM analysis with the fixed factors scene (reference: park), mask (reference: no mask), and emotion (reference: happy) on the emotion intensity rating, revealed significant fixed effect estimates for mask, β=−0.81, t=−11.55, p<.001, CI_{95_fe}[−0.95, −0.68], effect size (es, standardised coefficient)=−0.43, CI_{95_es}-[−0.51, −0.36], and emotion, β=−0.75, t=−9.28, p<.001, CI_{95_fe}[−0.88, −0.62], es=−0.40, CI_{95_es}[−0.48, −0.31]. The emotion*mask interaction, β=−0.65, t=−7.85, p<.001, CI_{95_fe}[−0.84, −0.47] was significant but did not qualify the main effects (see Figure 2, for estimated marginal means, standard errors, and 95% confidence intervals). The LMM analysis included a random intercept for the cluster variable participant id and random slopes for segment, scene, and mask. Contrast analyses (custom contrasts) indicated that when expressers wore a mask, the target emotion intensity was rated significantly lower in both happy (p<.001, Cohen's d=0.58) and sad faces (p <.001, Cohen's d=1.05). Scene had no significant predictive value (p=0.54) but was retained as the models including this variable had better fit (AIC: 17752 vs. 17791, BIC: 17855 vs. 17862, χ^2=49.00, p>.001) (for more detailed results and code, see R Markdown).

Interestingly, in accordance with hypothesis 1c, participants had higher ratings on the negative distractor emotions of the basic emotion profile (anger, fear, disgust) when rating sad faces with masks. The higher ratings on distractor items in the emotion profile confirm that wearing a mask reduced the clarity of the emotion signal (for more details, see R Markdown). On an exploratory note, there was also less intense overall emotion-profile use when rating happy faces with masks.

Perceived interpersonal closeness

An LMM analysis with the same factors on the perceived interpersonal closeness ratings revealed significant fixed effect estimates for mask, β=−0.30, t=−6.27, p<.001, CI_{95_fe}[−0.41, −0.19], es=0.20, CI_{95_es}-[−0.26, −0.14], and emotion, β=−0.78, t=−10.16, p<.001, CI_{95_fe}[−0.95, −0.62], es=−0.52, CI_{95_es}[−0.42, −0.62]. The emotion*mask interaction, β=0.13, t=2.42, p=.026, CI_{95_fe}[0.02, 0.24] was significant but did not qualify the main effects (see Figure 3, for plot). As indicated by contrast analyses (custom contrasts) and in accordance with hypothesis 2, participants felt closer to expressers without masks than with masks (happy: p<.001, Cohen's d=0.33; sad: p<.001, Cohen's d=0.19). Moreover, they felt closer to happy than sad expressers (no mask: p<.001, Cohen's d=0.89; mask: p<.001, Cohen's d=0.74). The fixed effect estimate for scene was β=−0.08, CI_{95_fe}-[−0.15, 0.00], p=.049, had no substantial predictive

Figure 2. Rated emotion intensity as a function of scene, mask, and emotion expression. Note: Symbols (circle: no mask, triangle: mask) represent estimated marginal means, black bars represent standard errors, coloured bars represent 95%-confidence intervals. The response scale ranged from 1 to 7.

value (p=0.20) but was retained as models with this variable had better fit (AIC: 13839 vs. 13915; BIC: 13943 vs. 13986; χ^2=85.7, p<.001). Thus, largely independent of the surroundings, participants felt socially closer to expressers not wearing masks. Notably, showing sadness compared to happiness also increased perceived social distance.

Facial mimicry

To assess whether mask-wearing impedes mimicry, we conducted LMM analyses with the fixed factors segment (reference: neutral expression/still face), scene (reference: park), and mask (reference: no mask) on the positive expressivity score for happy expressers and on the negative expressivity score for sad expressers. We included a random intercept for the cluster variable participant id and random slopes for segment, scene, and mask. Values significantly above zero indicate a matching expression by participants, values around zero indicate no expression, and values below zero indicate a counter-expression. Mimicry was indexed by (a) a pattern score significantly larger than zero or (b)

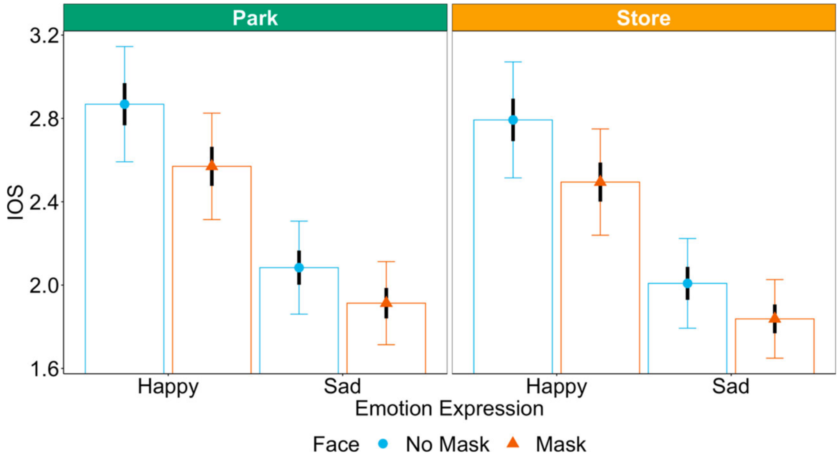

Figure 3. Perceived interpersonal closeness (IOS) as a function of scene, mask, and emotion expression. Note: Symbols (circle: no mask, triangle: mask) represent estimated marginal means, black bars represent standard errors, coloured bars represent 95%-confidence intervals. The response scale ranged from 1 to 7.

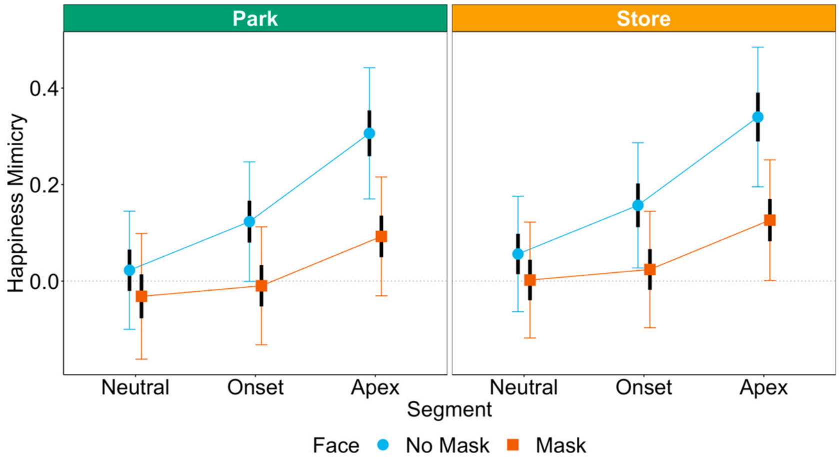

Figure 4. Facial activity in response to happy expressions (happiness mimicry) as a function of scene, mask, and segment.

scores for onset and apex, respectively, that are significantly larger than scores for responses to neutral expressions.

Happy expressions. An LMM analysis revealed significant fixed effect estimates for onset, β=0.10, t=2.19, p=.001, CI_{95_fe}[0.04, 0.16], es=0.10, CI_{95_es}[0.01, 0.18], and apex, β=0.28, t=5.45, p<.001, CI_{95}[0.18, 0.39], es=0.27, CI_{95_es}[0.17, 0.37], segments, which were qualified by the mask*onset interaction, β= −0.08, t=−1.25, p = .040, CI_{95_fe}[−0.15, 0.00], and the mask*apex interaction, β=−0.16, t=−2.44, p=.004, CI_{95_fe}[−0.27, −0.05] (see Figure 4, for plot). Scene had no significant predictive value (p=1.00) but was retained as the models with this variable had better fit (AIC: 16593 vs. 16699; BIC: 16746 vs. 16812; χ^2=118.00, p<.001). In all mentioned analyses, there was lack of support for hypothesis 4 in that scene did not moderate the effects of mask condition on our dependent variables but was retained in the models as it improved fit.

Comparisons of estimated marginal means to zero indicated that for unmasked expressers mimicry was present at apex in both contexts (park: CI_{95}[0.17, 0.44], store: CI_{95}[0.19, 0.49]); and also at onset in the store scene, CI_{95}[0.03, 0.29] and just failed to be significant for onset in the park scene, CI_{95} [−0.002, 0.25]. For masked expressers, mimicry was just significant only at an apex in the store scene, CI_{95} [0.0002, 0.25] and non-significant in all other conditions. Importantly, at apex, facial positivity in response to unmasked expressers was significantly higher than toward masked expressers (estimates=0.21, p=0.002, CI_{95}[0.05, 0.38]).

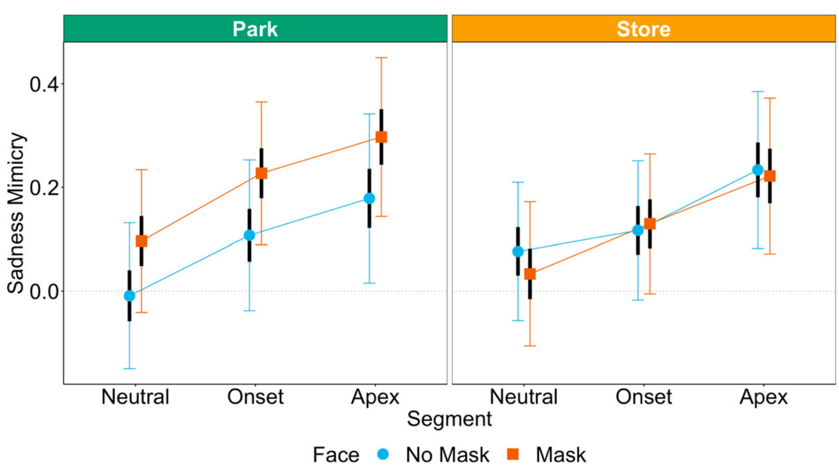

Figure 5. Facial activity in response to sad expressions as a function of scene, mask, and segment.

Moreover, as shown by contrast analyses (custom contrasts), facial positivity was higher at apex than at neutral for unmasked expressions (estimates: 0.28, $p<.001$, Cohen's d=.23), but not for masked expressions (p=0.16). Overall, in accordance with hypothesis 3, mimicry of happy expressions emerged consistently for unmasked expressers, but was reduced or absent when the expresser wore a mask.

Sad expressions. The full LMM model with the same experimental factors, revealed significant fixed effect estimates for onset, β=0.12, t=1.90, p=.010, CI_{95_fe}[0.00, 0.24], es=0.12, CI_{95_es} [0.00, 0.24], and apex, β=0.19, t=2.80, p=.006, CI_{95_fe}[0.05, 0.32], es=0.19, CI_{95_es} [0.06, 0.33], segments (see Figure 5, for plot). Based on the estimated marginal means comparisons to zero, facial negativity was different from zero at apex, indicating mimicry, for all conditions (min CI_{95_lb}=0.02, max CI_{95_ub}=0.45). By contrast, when comparing onset and apex to neutral, the difference was just significant only in response to mask wearers in the park (p=.032). Yet, a clearer pattern for sadness mimicry based on the apex/onset vs.-neutral criterion emerged for the segment-only model (with the non-significant fixed effects excluded), onset, β=0.10, t=3.01, $p<.001$, CI_{95}[0.05, 0.14], es=0.10, CI_{95_es} [0.03, 0.16], and apex, β=0.19, t=5.04, $p<.001$, CI_{95}[0.11, 0.26], es=0.19, CI_{95_es} [0.12, 0.27]. Thus, sadness mimicry was evident in all conditions, but not stable across all criteria (for an ancillary analysis with emotion as factor, including a plot of the data, see R Markdown). We conclude that hypothesis 3 was not supported in case of sadness mimicry in that masks seemed to have little influence on facial activity in perceivers.

The potential role of attitudes for emotional mimicry of masked expressions

According to the mimicry in context model (Hess & Fischer, 2013, 2016), negative attitudes toward mask-wearing should result in reduced mimicry. However, approval of masks was surprisingly high and homogeneous in our sample (Mean=6.4, SD=1.05 on a 7-point scale). This restriction of variance made modeling problematic and highlights the need to incorporate more sophisticated measures in future research.

The mediating role of emotion perception in the mask-mimicry relationship

Mediation of happiness mimicry. Next to the effect of attitudes on emotional mimicry, it is possible that the reduced perceived intensity of the expressions reduced mimicry, because the weaker signal is less clear. Conversely, embodiment accounts (Niedenthal et al., 2017) would predict reduced perception as a function of reduced mimicry. We therefore investigated the direction of the emotion perception-mimicry link. For happy expressions, multilevel mediation analyses revealed (controlling for scene), next to the direct effect of mask on facial positivity (−0.16, negative estimate indicates less positivity for mask vs. reference category no mask), an indirect effect of mask via perceived emotion intensity on happiness mimicry of −0.04 (i1=−0.82*i2 = 0.05). The total effect was −0.20 with a substantial proportion of mediation (21.7%). Thus, for happiness mimicry, there was support for hypothesis 5. By contrast, for the reverse direction (emotion intensity being predicted by mask via facial positivity), the indirect effect was significant (direct=0.70; indirect=0.02), but negligible with 97.4% of the total effect (0.04) attributable to the direct effect. This suggests that, in line with the mimicry as social regulator model (Hess & Fischer, 2013), the lack of perception clarity contributed to the reduction in mimicry rather than the reverse.

Mediation of sadness mimicry. For sad expressions, the corresponding analysis revealed only a direct effect of mask on facial negativity of 0.02. Thus, for sad expressions, the mask-mimicry relationship was not mediated by intensity and neither was the mask-intensity relationship mediated by mimicry (direct effect: −1.4) (for more detailed results and mediation plots, see R Markdown). Overall, there was evidence for the role of emotion perception as a mediator in case of happiness mimicry but no evidence for the role of facial mimicry as a mediator.

Discussion

In this study, we found support for hypothesis 1b (masks reduce perceived emotion intensity) and 1c (masks increase emotion recognition bias), hypothesis 2 (masks reduce perceived interpersonal closeness), in case of happiness mimicry, hypothesis 3 (masks reduce facial mimicry), and, also in case of happiness mimicry, hypothesis 5 (perceived emotion intensity mediates the relationship between mask condition and facial mimicry). We could not find support for hypothesis 1a (masks reduce emotion recognition rate) and hypothesis 4 (scene moderates the effect of mask condition on the dependent variables).

We used embedded, naturalistic face stimuli to assess the effect of masks on facial mimicry and emotion perception during the COVID-19 pandemic. Moreover, we used automated facial recognition technology to assess mimicry from videos uploaded from the participants' webcams. The results suggest that automated facial recognition can be a valuable alternative to electromyography for the analysis of facial behaviour including mimicry under conditions of limited laboratory access (as in recurring lockdowns).

First, we replicated findings based on static stimuli (Carbon, 2020; Grundmann et al., 2021) using naturalistic dynamic expressions (see also Langbehn et al., 2020). As in these studies, and in line with H1b, expressions were perceived as less intense when the face was partially covered with a mask. On the other hand, participants were still able to recognise both emotions (see also Calbi et al., 2021). Yet, reduced perceived emotion intensity itself can reduce perceived interaction quality for several reasons; for example, the reduced perceived affect could be perceived as inappropriate or as a rejection of the interaction partner. Also, masks reduce the perceiver's confidence in their own assessment (Carbon, 2020) and may thereby add uncertainty to the interaction. Future research could explore to what extent these issues, beyond mere emotion category recognition, impact real-life social interaction, for example via experience sampling approaches. Moreover, we found support for hypothesis 2 in that perceived interpersonal closeness, a facet of interaction quality, was reduced, or distance increased, when face masks were present (cf. Calbi et al., 2021; Grundmann et al., 2021).

Importantly, this study is the first to assess the effects of face masks on facial mimicry. We found, in partial support of hypothesis 3, that smile mimicry was affected when expressers wore masks. Interestingly, we found mimicry for both masked and unmasked faces with sad expressions, suggesting sadness mimicry may be relatively unimpeded by masks. The reduction in smile mimicry may be attributed to two processes in particular. First, facial mimicry depends on affiliation (Hess, 2021). If participants felt rejected by mask-wearers or otherwise consider interaction partners who wear a mask to somehow behave socially inappropriately or unexpectedly, they should not want to affiliate and, hence, mimic less (Kastendieck et al., 2020). Second, according to the mimicry in context perspective, we mimic what we infer from facial expressions rather than muscular patterns per se (Hess, 2021). Therefore, to the degree that the mask disturbs emotion perception, it should also impact on mimicry. This was indeed what we found for happy expressions. Mediation analysis suggested for happy expressions that to the degree that participants perceived happiness less intensely, they also showed less mimicry.

Interestingly, however, mimicry of sad expressions was not influenced by perceived emotion intensity, even though masks did have an impact on perceived intensity. This may be because sadness is a strong elicitor of empathy. Sad expressions appeal for help and succour (Scarantino, 2019). As such, they may also appeal at a more basic level to the observer. To the degree that mimicry is a path to empathy (Walter, 2012), sadness may in fact require less "verification" of the underlying social motive. Specifically, smiles are ubiquitous social signals of affiliation but also can have a number of other meanings (Niedenthal et al., 2010). In fact, smiles may even have negative meaning as in a smirk or when showing schadenfreude. As such, observers may implicitly trust a sad expression even when it is weak and unclear but hesitate to trust a smile expression unless it is definitely identified as benign. This effect may be stronger in a context in which an implicit negative attitude is present such as when people are wearing masks, which can increase perceived social distance.

Previous peri-pandemic studies have shown faces on blank screens. Instead, we presented faces in different contexts to approximate real-life encounters as we expected the scene context to make a difference in perceived appropriateness. Although we could not find pronounced scene effects in this study, controlling for scene improved model fit. This suggests that the scene accounted for some variance and should be taken into account. Although both actual risk and face mask use are more relevant inside, the use of face masks is advised as well when standing closely together outside (Asbach et al., 2020). We assumed that seeing people wearing masks in a store versus outside would affect mimicry differently, as we hypothesised that the mask-wearer's disregard for rules and consequently the perceiver's risk is higher in a context where the general risk of transmission is increased. Our findings point to the need for more research to explore further to what extent evaluation of context appropriateness based on scene-expression combinations interacts with emotion perception and empathy.

In sum, the present study suggests that face masks do not only reduce perceived emotion expression intensity, but also have an impact of an important process in establishing warm and pleasant interactions – facial mimicry of happy expressions. Together with evidence that reduced or absent mimicry may be harmful to social bonding (Mauersberger & Hess, 2019), our results suggest that face masks may indeed complicate social interactions in everyday life. However, it should be noted that in real interactions people also express emotions posturally and vocally and that these expressions also elicit facial mimicry (Hawk et al., 2012; Kret et al., 2013). As such, as long as people interact, they may still mimic and maintain interactional flow.

Note

1. In addition, participants were asked to estimate the perceived physical distance to the persons they had seen (overall rating on all targets in feet and inch) and to answer questions regarding the extent to which they felt affected by COVID-19, whether they or someone close to them was diagnosed with COVID-19, what type of face mask they wear themselves during the pandemic, and geographical data. Descriptively, the vast majority of participants reported that they wear masks (community=99, surgical=87, N95/valve=3, other=8); only three said that they do not. Similarly, participants showed strong endorsement of the idea that it is generally reasonable to wear masks (Mean=6.38, SD=1.05, skew=-1.85, kurtosis=3.22, 7-point scale, category 7=131 participants, cat. 6=34). In hindsight, asking specifically for indoor and outdoor contexts might have helped to reduce the distribution problem for this variable. One fourth of participants (49/200) reported they or someone in their immediate social circle had been sick with COVID-19. On average, participants felt moderately affected by the pandemic (Mean=4.02, SD=1.65, skew=0.1, kurtosis=-0.93, 7-point scale). Partly due to evident distribution issues, these variables did not moderate any of the reported effects. Perceived physical distance toward the targets overall was uncorrelated with interpersonal closeness in this sample.

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References

Aron, A., Aron, E. N., & Smollan, D. (1992). Inclusion of other in the self scale and the structure of interpersonal closeness. *Journal of Personality and Social Psychology*, *63*(4), 596. https://doi.org/10.1037/0022-3514.63.4.596

Asbach, C., Held, A., & Kiendler-Scharr, A. (2020). Position paper of the Gesellschaft für Aerosolforschung on understanding the role of aerosol particles in SARS-CoV-2 infection. *Association Aerosol Research*. *17*. https://doi.org/10.5281/zenodo.4350494

Baltrusaitis, T., Zadeh, A., Lim, Y. C., & Morency, L. P. (2018). Openface 2.0: Facial behavior analysis toolkit. In 2018 *13th IEEE international conference on automatic face & gesture recognition (FG 2018)* (pp. 59–66). IEEE. https://doi.org/10.1109/FG.2018.00019.

Baron-Cohen, S., Wheelwright, S., & Jolliffe, T. (1997). Is there a "language of the eyes"? Evidence from normal adults, and adults with autism or Asperger syndrome. *Visual Cognition*, *4*(3), 311–331. https://doi.org/10.1080/713756761

Bijlstra, G., Holland, R. W., Dotsch, R., Hugenberg, K., & Wigboldus, D. H. (2014). Stereotype associations and emotion recognition. *Personality and Social Psychology Bulletin*, *40*(5), 567–577. https://doi.org/10.1177/0146167213520458

Blaison, C., Hareli, S., Mauruschia, J., Strauss, C., & Hess, U. (2013). The effect of social context on facial mimicry to half visible faces and fully visible faces. *Psychophysiology*, *50*, S103–S104.

Boucher, J. D., & Ekman, P. (1975). Facial areas and emotional information. *Journal of Communication*, *25*(2), 21–29. https://doi.org/10.1111/j.1460-2466.1975.tb00577.x

Calbi, M., Langiulli, N., Ferroni, F., Montalti, M., Kolesnikov, A., Gallese, V., & Umiltà, M. A. (2021). The consequences of

COVID-19 on social interactions: An online study on face covering. *Scientific Reports*, *11*(1), 1–10. https://doi.org/10.1038/s41598-021-81780-w

Campbell, J. I., & Thompson, V. A. (2012). MorePower 6.0 for ANOVA with relational confidence intervals and Bayesian analysis. *Behavior Research Methods*, *44*(4), 1255–1265. https://doi.org/10.3758/s13428-012-0186-0

Carbon, C. C. (2020). Wearing face masks strongly confuses counterparts in reading emotions. *Frontiers in Psychology*, *11*, 2526. https://doi.org/10.3389/fpsyg.2020.566886

Drimalla, H., Landwehr, N., Hess, U., & Dziobek, I. (2019). From face to face: The contribution of facial mimicry to cognitive and emotional empathy. *Cognition and Emotion*, *33*(8), 1672–1686. https://doi.org/10.1080/02699931.2019.1596068.

Drimalla, H., Scheffer, T., Landwehr, N., Baskow, I., Roepke, S., Behnia, B., & Dziobek, I. (2020). Towards the automatic detection of social biomarkers in autism spectrum disorder: Introducing the simulated interaction task (SIT). *NPJ Digital Medicine*, *3*(1), 25. https://doi.org/10.1038/s41746-020-0227-5

Ekman, P., & Friesen, W. (1978). *The facial action coding system: A technique for the measurement of facial movement*. Consulting Psychologists Press.

Grundmann, F., Epstude, K., & Scheibe, S. (2021). Face masks reduce emotion-recognition accuracy and perceived closeness. *Plos One*, *16*(4), e0249792. https://doi.org/10.1371/journal.pone.0249792

Hareli, S., David, S., & Hess, U. (2013). Competent and warm but unemotional: The influence of occupational stereotypes on the attribution of emotions. *Journal of Nonverbal Behavior*, *37*(4), 307–317. https://doi.org/10.1007/s10919-013-0157-x

Hawk, S. T., Fischer, A., & Van Kleef, G. A. (2012). Face the noise: Embodied responses to nonverbal vocalizations of discrete emotions. *Journal of Personality and Social Psychology*, *102*(4), 796. https://doi.org/10.1037/a0026234

Hess, U. (2021). Who to whom and why: The social nature of emotional mimicry. *Psychophysiology*, *58*(1), e13675. https://doi.org/10.1111/psyp.13675

Hess, U., Arslan, R., Mauersberger, H., Blaison, C., Dufner, M., Denissen, J. J. A., & Ziegler, M. (2017). Reliability of surface facial electromyography. *Psychophysiology*, *54*(1), 12–23. https://doi.org/10.1111/psyp.12676

Hess, U., & Fischer, A. (2013). Emotional mimicry as social regulation. *Personality and Social Psychology Review*, *17*(2), 142–157. https://doi.org/10.1177/1088868312472607

Hess, U., & Fischer, A. (2016). *Emotional mimicry in social context*. Cambridge University Press.

Hess, U., Philippot, P., & Blairy, S. (1999). Mimicry: Facts and fiction. In *Studies in emotion and social interaction. The social context of nonverbal behavior* (pp. 213–241). Editions de la Maison des Sciences de l'Homme.

Kastendieck, T., Mauersberger, H., Blaison, C., Ghalib, J., & Hess, U. (2020). Laughing at funerals and frowning at weddings: Top-down influences of context-driven social judgments on emotional mimicry. *Acta Psychologica*, *212*, 103195. https://doi.org/10.1016/j.actpsy.2020.103195

Knutson, B. (1996). Facial expressions of emotion influence interpersonal trait inferences. *Journal of Nonverbal Behavior*, *20*(3), 165–182. https://doi.org/10.1007/BF02281954

Kret, M. E., Roelofs, K., Stekelenburg, J. J., & de Gelder, B. (2013). Emotional signals from faces, bodies and scenes influence observers' face expressions, fixations and pupil-size. *Frontiers in Human Neuroscience*, *7*(810), https://doi.org/10.3389/fnhum.2013.00810

Langbehn, A., Yermol, D., Zhao, F., Thorstenson, C., & Niedenthal, P. (2020). Wearing N95, surgical and cloth face masks compromises the communication of emotion. *Research Square*. https://doi.org/10.21203/rs.3.rs-133686/v1.

Mauersberger, H., & Hess, U. (2019). When smiling back helps and scowling back hurts: Individual differences in emotional mimicry are associated with self-reported interaction quality during conflict interactions. *Motivation and Emotion*, *43*(3), 471–482. https://doi.org/10.1007/s11031-018-9743-x

Niedenthal, P. M., Mermillod, M., Maringer, M., & Hess, U. (2010). The simulation of smiles (SIMS) model: Embodied simulation and the meaning of facial expression. *Behavioral and Brain Sciences*, *33*(6), 417. https://doi.org/10.1017/s0140525x10000865

Niedenthal, P. M., Wood, A., Rychlowska, M., & Korb, S.. (2017). Embodied simulation in decoding facial expression. In J. Fernandez-Dols & J. Russell (Eds.), *The Science of Facial Expression* (pp. 397–414)). Oxford, UK: Oxford University Press.

Olivera-La Rosa, A., Chuquichambi, E. G., & & Ingram, G. P. (2020). Keep your (social) distance: Pathogen concerns and social perception in the time of COVID-19. *Personality and Individual Differences*, *166*, 110200. https://doi.org/10.1016/j.paid.2020.110200

Qian, H., Miao, T., Liu, L., Zheng, X., Luo, D., & Li, Y. (2021). Indoor transmission of SARS-CoV-2. *Indoor Air*, *31*(3), 639–645. https://doi.org/10.1101/2020.04.04.20053058

Ruba, A. L., & Pollak, S. D. (2020). Children's emotion inferences from masked faces: Implications for social interactions during COVID-19. *Plos One*, *15*(12), e0243708. https://doi.org/10.1371/journal.pone.0243708

Scarantino, A. (2019). Affective pragmatics extended: From natural to overt expressions of emotions. In U. Hess & S. Hareli (Eds.), *The social Nature of emotion expression* (pp. 49–81). Springer.

Schmidtmann, G., Logan, A. J., Carbon, C.-C., Loong, J. T., & Gold, I. (2020). In the blink of an Eye: Reading mental states from briefly presented Eye regions. *i-Perception*, *11*(5), 2041669520961116. https://doi.org/10.1177/2041669520961116

Vacaru, S. V., van Schaik, J. E., & Hunnius, S. (2019). The modulation of facial mimicry by attachment tendencies and their underlying affiliation motives in 3-year-olds: An EMG study. *Plos One*, *14*(7), e0218676. https://doi.org/10.1371/journal.pone.0218676

van Bavel, J. J., Baicker, K., Boggio, P. S., Capraro, V., Cichocka, A., Cikara, M., Crockett, M. J., Crum, A. J., Douglas, K. M., & Druckman, J. N. (2020). Using social and behavioural science to support COVID-19 pandemic response. *Nature Human Behaviour*, *4*(5), 460–471. https://doi.org/10.1038/s41562-020-0884-z

van der Schalk, J., Hawk, S. T., Fischer, A. H., & Doosje, B. J. (2011). Moving faces, looking places: Validation of the Amsterdam Dynamic Facial Expression Set (ADFES). *Emotion*, *11*(4), 907. https://doi.org/10.1037/a0023853

Walter, H. (2012). Social cognitive neuroscience of empathy: Concepts, circuits, and genes. *Emotion Review*, *4*(1), 9–17. https://doi.org/10.1177/1754073911421379

Wong, C. K. M., Yip, B. H. K., Mercer, S., Griffiths, S., Kung, K., Wong, M. C.-S., Chor, J., & Wong, S. Y.-S. (2013). Effect of facemasks on empathy and relational continuity: A randomised controlled trial in primary care. *BMC Family Practice*, *14*(1), 1–7. https://doi.org/10.1186/1471-2296-14-200