The effect of face mask wearing on language processing and emotion recognition in young children

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Lorna Bourke [a],[*], Jamie Lingwood [a], Tom Gallagher-Mitchell [a], Belén López-Pérez [b]

[a] Department of Psychology, Liverpool Hope University, Liverpool L16 9JD, UK
[b] School of Health Sciences, University of Manchester, Manchester M13 9NT, UK

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ABSTRACT

Face mask wearing was an important preventative strategy for the transmission of the COVID-19 virus. However, the effects that occluding the mouth and nose area with surgical masks could have on young children's language processing and emotion recognition skills have received little investigation. To evaluate the possible effects, the current study recruited a sample of 74 children from the North West of England (aged 4–8 years). They completed two computer-based tasks with adults wearing or not wearing surgical face masks to assess (a) language processing skills and (b) emotion recognition ability. To control for individual differences, age, sex, receptive vocabulary, early reading skills, and parent-reported social–emotional competence were included in analyses. The findings from the study highlighted that although younger children were less accurate than older children, face masks did not significantly impair basic language processing ability. However, they had a significant effect on the children's emotion recognition accuracy—with masked angry faces more easily recognized and masked happy and sad faces less easily recognized. Children's age and social-emotional skills also played a role. The findings suggest that the effects of face masks should continue to be evaluated.

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* Corresponding author.
  E-mail address: bourkel@hope.ac.uk (L. Bourke).

Introduction

Children globally were impacted academically, emotionally, and in connecting with others by the COVID-19 pandemic (Cowie & Myers, 2021). As restrictions were lifted, face mask wearing was advised in public places and schools to minimize transmission of the virus, especially where social distancing was limited. Given the importance of visual communication for children's language acquisition and social-emotional development (Chronaki et al., 2015), concern was manifested that face masks could impair those skills. This could have negative implications for children's progress in education as well as when building relationships with peers and teachers during a sensitive period of development for both language and social-emotional skills (Charney et al., 2021). The current experimental study examined this important issue because the findings could help to clarify some of the psychological consequences of face mask wearing.

Language processing and face mask wearing

Spoken language comprehension involves the integration of phonetic, lexical, and syntactic information (Truong et al., 2021). Young children (i.e., 4–8 years of age) make better progress in language and literacy when they can process and maintain phonological representations more efficiently (Bourke & Adams, 2003). To test children's progress on their awareness of decoding phonological representations, checklists that measure their ability to listen to and repeat back nonwords are administered (e.g., Children's Test of Nonword Repetition [CNRep]; Gathercole & Baddeley, 1996). Although effective acoustic attenuation is essential for the task (Palmiero et al., 2016), competency in processing of incoming speech-based information is supplemented by visual cues (Saunders et al., 2021).

The challenge for young children is that face masks occlude 60 % to 70 % of the face, blocking speech reading cues (Carbon, 2020; Saunders et al., 2021). There is some support for the detrimental effect of face mask wearing on the listener's recall of words in spoken sentences in adults (Yi et al., 2021). This was explained as face masks making the task more cognitively demanding and strongly influencing encoding information in memory when the speech signals become degraded or ambiguous (Truong et al., 2021). Therefore, the first aim of the current study was to investigate whether the intelligibility of the speech signal associated with one of the foundational skills for literacy (i.e., phonological awareness) (Lingwood et al., 2020) could be compromised for young children when the speaker wears a mask (Charney et al., 2021).

Emotion recognition and face mask wearing

Facial expressions support the inferences about the emotions and intentions of others (Calbi et al., 2021) affecting the social behavior of the observer (Guarnera et al., 2015). Therefore, sensitivity to facial emotion recognition is fundamental to children's social competence (Chronaki et al., 2015). The visual system is adept at identifying specific processing units for generating categories of emotion (Blais et al., 2012). However, the developmental trajectory of emotion processing for young children differs as a function of emotion type and task demands. Happiness and sadness are better categorized (i.e., recognized above chance) at 6 to 10 years of age due to better definition and greater clarity between feature boundaries (Durand et al., 2007). Discrimination accuracy improves with age across a fuller range of emotions (e.g., fear, anger, disgust) and reaches adult performance at 11 years of age as children gradually become more able to rely on the configural properties of faces and less on the piecemeal nature of featural, componential, or local processing (Durand et al., 2007).

Sufficient feature-based information needs to be available for accurate recognition of emotions (Blais et al., 2012). There is mixed evidence that wearing masks impairs emotion recognition in adults (Calbi et al., 2021; Carbon, 2020; Saunders et al., 2021). Where there is an impact (Grundmann et al., 2021), the mouth region appears to be of uppermost importance in reading emotions, especially positive emotions (e.g., happiness) (Blais et al., 2012). Data exploring the emotion recognition costs of wearing face masks indicate that a greater challenge is posed for children aged 3 to 5 years compared with 6- to 10-year-olds (Gori et al., 2021). Given the scarce evidence, the second aim of the study was

to further evaluate the impact of face masks on emotion recognition in children but controlling for children's emotional competence (Merrell et al., 2011). We controlled for emotional competence because children's social-emotional abilities can play an important role. Those exhibiting higher social-emotional skills are better at reading others' emotions given the positive correlation among emotion identification, understanding, and regulation (Southam-Gerow & Kendall, 2002). The experimental methodology was adapted from Calbi et al. (2021) for adult participants to investigate whether children differ in their emotion recognition abilities depending on whether the static facial expression of emotions (i.e., happy, angry, and sad) is masked or unmasked.

The current study

Based on previous research, we expected that performance on the language task would be relatively impacted when the speaker wears a surgical mask, especially for nonwords containing a greater number of syllables (ranging from 2 to 5) because cognitive load may increase (Truong et al., 2021). We expected this pattern even when controlling for age, sex, listening comprehension, and reading skill. For emotion recognition, it was anticipated that after controlling for age, sex, and social-emotional competence, face masks would have a detrimental effect on young children's ability to recognize emotions. However, we expected a higher impairment for the recognition of happiness as compared with sadness and anger given that the mouth region appears to be more important for the accurate identification of this emotion (Blais et al., 2012).

Method

Participants

A total of 74 children from the North West of England aged 4 to 8 years (M_{age} = 6 years 5 months, SD = 15.61 months; 36 boys and 38 girls) and their primary caregivers (8 % fathers and 92 % mothers; M_{age} = 37.51 years, SD = 4.99) participated in the study. The sample was determined by an a priori power analysis (see online supplementary materials, including "Children's first language" section). There were no exclusion criteria for this study. The research was carried out in accordance with the university's ethical guidelines for investigations involving vulnerable human participants. Participants' caregivers gave their written consent for participation and children provided assent before taking part. All children were awarded a Young Scientist certificate, and their parents were e-mailed a £10 Amazon voucher.

General procedure

Families participated in the research study either face to face in the ChildLab facility at Liverpool Hope University (31 %), or virtually via Zoom (69 %). This was to remove and/or reduce the impact of any barriers to participation such as traveling to the campus, cost of travel, working hours and school hours, and parents' concern for face-to-face interactions due to COVID-19. Prior to testing, parents completed the questionnaire assessing their children's social-emotional competence. The tasks were counterbalanced within each testing session.

Materials

Full details on materials and stimuli can be found online at the Open Science Framework (https://osf.io/xzhvy)

Language processing

The CNRep (Gathercole & Baddeley, 1996) consists of 40 nonwords. An adult female speaker was recorded live saying each of the nonwords both with and without wearing a disposable surgical mask. Children were given two practice words before beginning the task, which was divided into four blocks

of 10 nonwords of 2 to 5 syllables in length (e.g., glistow–prisoractional) and was presented in a randomized order. They scored 1 point for each nonword repeated correctly. Error type (e.g., insertion and omission of phonology) was not analyzed. Internal consistency reliability reported for the task is $r =.77$.

Listening comprehension

The Wechsler Individual Achievement Test–Third Edition (WIAT-III; Wechsler, 2017) listening task was used. The child needed to identify the correct image from a template of four images that corresponded to the word spoken by the experimenter. The child scored 1 point for a correct response, and 0 points were recorded for an incorrect response. Internal consistency reliability reported for the task is $r =.83$.

Reading ability

The WIAT-III (Wechsler, 2017) early reading skills test was used. The child was required to identify letters and rhyming words and to match words to images. The child scored 1 point for a correct response, and 0 points were recorded for an incorrect response. Internal consistency reliability reported for the task is $r =.88$.

The raw scores for all materials were converted to age-related standardized scores for further analyses.

Emotion recognition

The emotion recognition task was built using PsychoPy (Peirce et al., 2019) and run via Pavlovia. Children were shown a series of static masked and unmasked male and female adult faces on the computer screen and were asked to identify how the person was feeling. The stimuli for this task were taken from the FACES database (Ebner et al., 2010). There were a total of 72 trials, 12 of which were practice trials. In the remaining 60 trials, stimuli were divided into blocks of 15 and repeated four times. A face stimulus appeared in the center of the screen after a fixation cross of 1 s. For the purpose of the current study, we were interested in emotion recognition accuracy, and latency was not recorded to ensure that the focus was on this rather than speed of response. At the bottom of the screen, there were happy, angry, and sad emoticons to help the child identify how the person was feeling. The child pointed to or said which emoticon was correct. The researcher pressed the corresponding key—happy (h), angry (a), sad (s), or unsure (d).

Social-emotional competence

Social Emotional Assets and Resilience Scale–Parent (SEARS-P; Merrell et al., 2011). Parents rated their children's social-emotional strengths (i.e., empathy, social competence, and self-regulation/responsibility) over the past 6 months across 39 statements on a 4-point Likert scale ranging from 1 = *never true* to 4 = *always true* (e.g., empathy: "understands how other people feel"; social competence: "makes friends easily"; self-regulation/responsibility: "stays in control when he/she gets angry"). The total score was included in the analyses (Cronbach's $\alpha =.96$).

Results

Preliminary analyses

One participant was removed due to scoring well below the average minimum score for the child's age on the CNRep (see supplementary material). Before running any analyses, we established that there was a significant difference between children who were tested face-to-face and those who were tested virtually via Zoom (i.e., mode of testing) in the language processing experiment. Those tested face-to-face outperformed those who were tested in a Zoom situation. No differences were found for the emotion recognition task (see supplementary material). Therefore, mode of testing was included as a control variable in later analyses only for the language processing experiment. Independent t tests revealed that children assigned to the mask-wearing condition (mask or no mask) were

matched on core skills that could potentially impact language processing (Table 1). The distributions of the observed values were explored, and the skewness statistic was within an acceptable range for all variables (−1 to + 1) (Field, 2013).

Language processing and face mask wearing

A correlation analysis indicated that the performance scores for the CNRep improved with age (r =.51, p <.001, r^2 =.03). A univariate analysis of variance (ANOVA) with condition (mask or no mask) as a between-participant factor was conducted to evaluate whether performance on the CNRep was affected. We controlled for mode of testing (face-to-face or Zoom), age, sex, listening comprehension, and reading ability by adding these as covariates. The results did not show a significant difference between the mask and no mask conditions, $F(1, 66) = 0.70$, p =.40, η_{p}^{2} =.01 (Table 1).

A two-way mixed ANOVA with condition (mask or no mask) as the between-participant factor and syllable length (2, 3, 4, or 5) as the within-participant factor, and with mode of testing (face-to-face or Zoom), age, sex, listening comprehension, and reading ability as covariates, revealed that there was no significant main effect for syllable length, $F(3, 198) = 2.50$, p =.06, η_{p}^{2} =.04, and no significant Syllable Length × Condition interaction, $F(3, 198) = 1.25$, p =.29, η_{p}^{2} =.02 (Table 1).

Emotion recognition and face mask wearing

We conducted a repeated-measures ANOVA with emotion (anger, happiness, or sadness) and condition (mask or no mask) as within-participant factors to evaluate whether participants' level of emotion accuracy might be affected. We controlled for age, sex, and children's parent-reported emotional competence, adding these as covariates, but not mode of testing because the preliminary analyses suggested that the accuracy of emotion recognition was not influenced by whether the presentation of stimuli was face-to-face or via Zoom. Results showed a significant Emotion × Condition interaction, $F(2, 67) = 3.90$, p =.02, η_{p}^{2} =.05 (Table 2). Pairwise comparisons showed that whereas anger ($d = 14.06$, $SE = 3.03$, p <.001) was better recognized in the mask condition, happiness ($d = −7.25$, $SE = 1.57$, p <.001) and sadness ($d = −37.89$, $SE = 2.63$, p <.001) were better recognized in the no mask condition. Overall, happiness was better recognized than sadness ($d = 13.09$, $SE = 2.25$, p <.001) and anger ($d = 20.46$, $SE = 1.54$, p <.001), $F(2, 67) = 3.48$, p =.03, η_{p}^{2} =.05 (Table 2; see also Fig. 1 in the supplementary material), and the presentation of unmasked faces led to better recognition ($d = 10.36$, $SE = 1.62$, p <.00), $F(2, 140) = 14.32$, p <.001, η_{p}^{2} =.17.

Although none of the interactions with age or gender was significant (see supplementary material), nor was the main effect of sex, $F(1, 70) = 0.10$, p =.76, η_{p}^{2} =.001 (Table 2), there was a significant effect of age, $F(1, 70) = 9.80$, p =.003, η_{p}^{2} =.12 (Table 2). In detail, age was positively linked with higher recog-

Table 1
Descriptive statistics and analyses of variance for language measures.

Language measure	Face mask condition		No face mask condition		Test statistic		Effect size
	Mean (*SD*)	Min–Max	Mean (*SD*)	Min–Max	t	p	Hedges' *g*
Listening comprehension	114.12 (16.93)	84–157	108.08 (15.97)	70–137	1.57	0.12	0.04
Reading skill	98.15 (14.99)	69–143	96.79 (13.49)	70–131	0.41	0.69	0.09
					F	p	η_{p}^{2}
CNRep accuracy	108.26 (18.68)	50–135	104.18 (16.64)	58–137	0.70	.40	.01
2-Syllable	8.38 (1.48)	4–10	7.67 (1.46)	5–10	4.33	.04	.06
3-Syllable	7.56 (1.44)	3–10	7.05 (1.82)	4–10	1.71	.19	.02
4-Syllable	5.85 (1.81)	2–9	6.05 (2.23)	1–10	0.17	.68	0
5-Syllable	6.70 (1.75)	3–10	6.33 (2.23)	1–10	0.62	.43	.01
Syllable length					2.50	.06	.04
Syllable Length × Condition					1.25	.29	.02

Note. CNRep, Children's Test of Nonword Repetition.

Table 2

Descriptive statistics and analyses of variance for emotion measures.

Emotion measure	Overall Mean (SD)	Min–Max	Face mask condition Mean (SD)	Min–Max	No face mask condition Mean (SD)	Min–Max	F	p	η_p^2
Emotional competence	72.69 (19.27)	10–117							
Emotion recognition accuracy			79.27 (14.09)	16.33–100	89.78 (9.03)	66.33–100	6.06	.01	.15
Anger			89.49 (22.72)	0–100	75.71 (23.75)	0–100			
Happiness			91.96 (13.60)	33–100	99.30 (5.89)	50–100			
Sadness			56.37 (21.02)	0–100	94.33 (12.97)	50–100			
Emotion × Condition × Competence							7.50	<.001	.10
Emotion × Condition							3.90	.02	.05
Condition							14.32	<.001	.17
Sex							0.10	.76	.001
Age							9.80	.003	.12

nition accuracy in the mask condition ($r =.35$, $p =.002$), but there was not a significant correlation with higher accuracy in the no mask condition ($r =.17$, $p =.13$). Age was positively linked with higher recognition in the mask condition for anger ($r =.26$, $p =.02$) and sadness ($r =.29$, $p =.013$). Finally, there was a significant Emotion × Condition × Children's Emotional Competence interaction, $F(2, 67) = 7.50$, $p <.001$, $\eta_{\text{p}}^2 =.10$ (Table 2). Children's parent-reported emotional competence was significantly linked with higher recognition accuracy for sadness in the mask condition ($r =.27$, $p =.01$). However, it was not significantly linked to higher recognition accuracy for the other emotions (see supplementary material).

Discussion

The aim of this study was to compare the influence of face mask wearing and no face mask wearing on language processing and emotion recognition in young children aged 4 to 8 years. We looked at language because face masks could potentially have a negative impact on children's ability to learn the phonological forms of new words important for reading and writing (Gathercole, 2006). We examined emotion recognition because correctly identifying how others are feeling is key to appropriate social-emotional development (Kwon & López-Pérez, 2022). Unlike what was hypothesized, the results showed that face masks did not have an effect on language. The wearing of a mask by the speaker did not significantly influence the speaker's performance. This is contrary to evidence from previous studies where participants self-reported the detrimental effects of face masks on verbal communication (Saunders et al., 2021).

Nonetheless, the findings are congruent with experimental studies indicating that intelligibility of speech by the listener, measured by the speech transmission index, is relatively unaffected when disposable surgical masks are worn (Palmiero et al., 2016). One explanation for the current findings is that the production of the phonological units of speech (i.e., phonemes, syllables) involves the articulation of mouth movements. They appeared to be relatively unhindered by the covering of the mouth/nose area. It may be that there was enhanced visibility of the sound patterns from the effects of aspiration causing movement against the mask itself, compensating for any degradation of the auditory signal (Charney et al., 2021). Surprisingly, speech-based cognitive load (measured by increase in syllable length) did not significantly impede performance overall (Truong et al., 2021). A more challenging language processing task may be required to estimate its impact more effectively.

The hypotheses for the influence of face mask wearing on emotion recognition were partially supported. Results showed that whereas anger was better recognized, happiness and sadness were impaired in their recognition. The better recognition of anger seems to be in direct contradiction with previous findings with adults where it was significantly impaired, as were happiness and sadness (Carbon, 2020). Anger recognition appears to be enhanced when focusing on the eye region, which may explain the findings obtained in the face mask condition. This is in line with previous evidence in which the eye and mouth regions were occluded separately in different trials, showing that anger recognition was significantly improved in the condition where the mouth was occluded as compared with the eyes (Wegrzyn et al., 2017). The impairments observed for happiness and sadness are in line with previous findings with adults (Carbon, 2020). Therefore, the differential impact of face masks on emotion recognition can have an effect on children's social interactions. For example, better recognition of anger can facilitate greater physical and social distance from one another (Calbi et al., 2021). On the other hand, lower recognition of happiness and sadness can be potentially detrimental for children's social interactions. Happiness has been identified as key to boosting social interactions (Quoidbach et al., 2019), whereas recognizing sadness in others is important to display appropriate interpersonal emotion regulation (Kwon & López-Pérez, 2022).

Age was significantly linked to better performance in the mask condition. This result is not surprising given that children become more competent in their emotion recognition and understanding as they get older (Lawrence et al., 2015). In addition, it may be possible that older children are able to compensate based on prior learning before the pandemic, whereas younger children might not have fully developed those skills. Interestingly, parent-reported social-emotional competence positively moderated the ability to recognize sadness when the expression was masked. This result suggests that

potentially more advanced social-emotional skills may counteract the negative effects of facemasks given that previous research has suggested that social-emotional functioning indeed has an important role in emotion recognition (Carbon, 2020).

Limitations and future research

There are factors that need to be considered before drawing main conclusions. One factor is the differences between the stimuli for measurement of language processing and emotion recognition. The former involved dynamic production of sound-based combinations of nonwords, and the latter involved static representation of emotion expression. In fact, static presentation of emotion without the information that is present from the dynamic progression of a visible expression can lower performance recognition (Blais et al., 2012). This is likely to contrast with how learning new words in a school classroom would happen or how emotions would be identified in real social interactions. Future research should consider more ecologically valid ways of assessment.

Conclusion

More research should evaluate the role that mask wearing plays in both language processing and emotion recognition. Both are important to the lives of young people. If one element of language processing is relatively unimpacted by the obscuring of visual cues, and the acoustic signal and speech perception are still intelligible by surgical mask wearing, then excessive noise in the environment may still be an important factor to consider (Truong et al., 2021; Yi et al., 2021). Alternatively, if the inhibition of a range of emotional displays leaves children largely mimicking negative emotions, then this can influence group cohesion in the classroom. For teachers and parents, this may present an opportunity to modify their behavior while wearing masks through body posture and body language (e.g., head orientation, gestures) to ensure that social communication and behavioral norms are aligned. Therefore, although children may have challenges with reading and language in the recovery from the pandemic, it is important that emotional development is not forgotten.

Author contributions

Lorna Bourke: conceptualization, methodology, formal analysis, investigation, resources, data curation, writing–original draft, reviewing and editing, and project administration; **Jamie Lingwood**: conceptualization, methodology, formal analysis, investigation, resources, data curation, writing–original draft, reviewing and editing, funding acquisition, and project administration; **Tom Gallagher-Mitchell**: conceptualization, software, and investigation resources; **Belén López-Pérez**: conceptualization, methodology, formal analysis, writing–original draft, and reviewing and editing.

Data availability

Full detail on materials and stimuli can be found online: https://osf.io/xzhvy

Acknowledgments

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jecp.2022.105580.

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