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ORIGINAL ARTICLE

Facial Expression Recognition in Mask-wearing Faces in Japanese Preschool Children

Seiji KOGA[1] Mizuki YOSHINAGA[2] Haruki KOCHO[1] Haruo FUJINO[3]

1) Department of Special Needs Education, Oita University
2) Matsubase Special Needs School
3) Department of Child Development, United Graduate School of Child Development, Osaka University

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skoga@oita-u.ac.jp（Seiji KOGA）

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ABSTRACT

Due to the COVID-19 pandemic, wearing a mask has become commonly implemented in school life. Compared to adults, there is a lack of knowledge on the effects of mask-wearing on facial expression recognition in children. Hence, this study aimed to investigate this relationship for Japanese preschool children. We collected data from 58 children aged 3–5 years. The children were asked to indicate the type of facial expression from 18 facial expression stimuli that were displayed individually on a screen, consisting of three types of facial expressions (happy, anger, and sadness) × three levels of emotional intensity (weak, moderate, strong) × with or without a mask. The global correct response rate was 86% in preschool children. Wearing a mask significantly reduced correct responses in children (88 to 83%). Happy and stronger emotional intensity (moderate to strong) was associated with higher accuracy. The results suggest that the effect of wearing a mask on facial expression recognition is significant; however, the effects are limited in preschool children.

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I. Introduction

The COVID-19 pandemic led many people to be forced to wear masks. The proportion of people who wear masks is particularly high in Japan. According to a survey by the Nippon Research Center[1], the proportion of people in Japan who said they would wear masks in public was 89% in April 2021 and 87% in April 2022, the highest among the 14 countries surveyed. Wearing a mask is one of the most significant social changes in the 'new lifestyle' encouraged by the Ministry of Health, Labour, and Welfare in response to the COVID-19 pandemic in Japan[2].

Challenges with face masks may include difficulties related to the recognition of faces and facial expressions; studies have demonstrated that facial expressions are one of the most important pieces of information in communicating emotions and attitudes[3]. When recognising face pictures, facial features are processed as a whole rather than in parts [4-6], and the mouth is critical in understanding the expressions of individuals[7]. Recent studies in adults following the COVID-19 pandemic have shown that wearing a mask makes it difficult to distinguish between people's faces and that it can interfere with facial expression recognition[8-9]. Carbon explored whether face masks interfere with facial expression recognition for six different emotions (angry, disgusted, fearful, happy, neutral, and sad) and found reduced accuracy for all emotions, except for fearful and neutral stimuli[10]. Marini et al. also reported that face masks interfere with emotion recognition for fear, happiness, and sadness[11]. Grahlow et al. used a large sample of 790 individuals to assess the recognition of six emotions (anger, disgust, fear, happiness, neutral, and sadness) and found that expression recognition accuracy was reduced with masks compared to without masks for all the emotions[12].

Due to the COVID-19 pandemic, wearing a mask was required of school staff, which may have influenced children's perception of emotions. Several studies have investigated this issue in preschool- and school-aged children. Gori et al. reported that wearing a mask affects facial expression recognition, particularly in preschool children, compared with school-age children and adults[13]. However, other studies have reported different results. For example, another study showed significant interference with recognition in school-aged children (7–13 years old), but the impact was not large[14]. In contrast, Roberson et al. observed a difference in the effect of mask-wearing on emotion recognition for children aged 9 years, while the difference was not clear between 3 and 8 years of age[15]. Carbon & Serrano also reported a significant decline in most emotions in school-age children, with patterns differing among the emotions[16]. Although studies are accumulating on the effects of mask-wearing on preschool children's recognition of facial expressions, inconsistencies in the findings indicate that further exploration is required in various settings.

Most prior studies have been conducted in Western countries. Cultural differences in the facial features used to assess expressions have been reported, including a stronger preference for eyes in Asian than in Western cultures[17-18]. Since such differences have

been observed in early childhood[19], investigations with Japanese preschool children may provide insight into the relationship between wearing facial masks and inference with emotion recognition by children. According to Gori et al., the effects of masks are particularly significant in children aged 3–5 years[13]. Therefore, we aimed to investigate the relationship between wearing a mask and correct facial expression recognition in preschool children in Japan. The influence of wearing a mask on the development of emotions' inference and the development of social interactions capabilities has received much attention[13], so it is important to study this topic.

II. Methods

1. Participants

Young children aged 3–5 years attending three nursery schools located in the study area (Oita, Japan) were recruited for the experiment. To be eligible for this study, participants were required to understand the practice exercises and experimental tasks. To confirm that the participants understood the tasks, two facial expression recognition exercises were initially conducted. Children who responded correctly to both exercises took part in the subsequent experiments. One child who did not respond correctly was excluded. A total of 58 preschool children (18 3-year-olds, 20 4-year-olds, and 20 5-year-old children; 29 boys and 29 girls) were included in this study. Although sample size calculation was not conducted before the data collection, we referred to a previous study investigating the effect of facial masks in preschool children (age range: 3–5 years, n = 31) [13]. The number of participants in that study was used as a minimum criterion for the current study. This study was conducted between September and December 2021.

2. Ethical Considerations

We explained to each facility that (a) the data obtained for this study would not be used for any purpose other than research, (b) the privacy and rights of the respondents would not be violated by participation in this study, (c) we did not collect any personally identifiable information, and (d) if the participating children refused, they would not be forced to participate in the experiment. The experiment was conducted after obtaining approval in orally from the head of each facility and orally explained the study to the parents of the children to provide opportunities to deny the participation. After data acquisition, the first and second authors provided assurance that no personally identifiable information was collected. The above procedures were reviewed and approved by the Research Ethics Committee of the Faculty of Education, Oita University following data acquisition (approval no. R5-002).

3. Experimental Stimuli

1) Apparatus

Facial stimuli were created for this study. Based on their frequent use in previous studies, we selected three facial expressions: happiness, anger, and sadness. We also manipulated the intensity of the expressed emotions to investigate possible effects of emotional intensity on facial expression judgements.

Eight university students (all female) were recruited to generate the stimuli for this study. The students were instructed to facially express three emotions (happiness, anger, and sadness) at three levels (weak, medium, and strong), resulting into nine facial expression stimuli for each individual. The expressions were photographed. Four participants' pictures were selected as materials to create experimental stimuli, which were judged by two investigators (SK and MY) as clearly expressing the target emotion. The facial expressions of the four individuals were combined using an application (Average Face PRO 4.7) to create facial expression stimuli without a facial mask. Second, we composited mask images onto each stimulus to create masked stimuli using image-editing software (GIMP 2.10.24). Consequently, we obtained nine images (i.e., three facial expressions x three intensities) with and without masks, respectively (Figure 1).

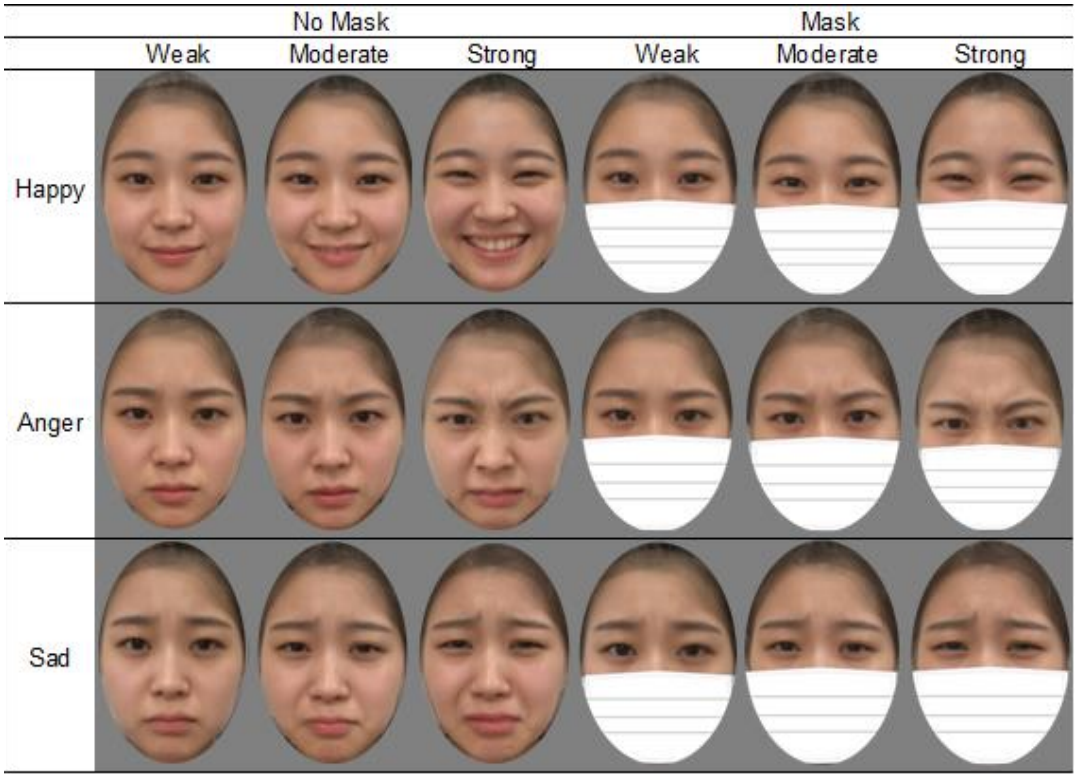

Figure 1. Facial stimuli of three emotions and intensities (happy, anger, and sad)

2) Evaluation of the stimuli

Twenty university students (evaluators) were asked to evaluate the stimuli. Ten students evaluated the unmasked stimuli (i.e., nine images), and the other 10 students evaluated the masked stimuli (i.e., nine images). They were asked to indicate whether each stimulus expressed happiness, anger, or sadness.

The order of presentation of facial expression stimuli was counterbalanced. Based on the literature, adults were expected to respond correctly given a limited response selection; therefore, we expected a relatively high percentage of correct responses. In the mask condition, the correct response proportion was 80% for weak happiness, 90% for weak anger, and 100% for other conditions. In the without mask condition, the correct response proportion was 100% except for weak anger (90%). The evaluators were also asked to rate the intensity of the emotion on a six-point scale, with '1' representing 'not at all expressed' and '6' representing 'strongly expressed'. The order of the intensity was correctly recognised in 95% of the stimuli in the without a mask condition and 81% in the masked condition (Figure 2).

These results suggest that adults accurately discriminate between differences in emotional intensity, regardless of the facial mask. Therefore, the stimuli created in this study appropriately expressed the three types of facial expression and emotional intensity in the pilot test.

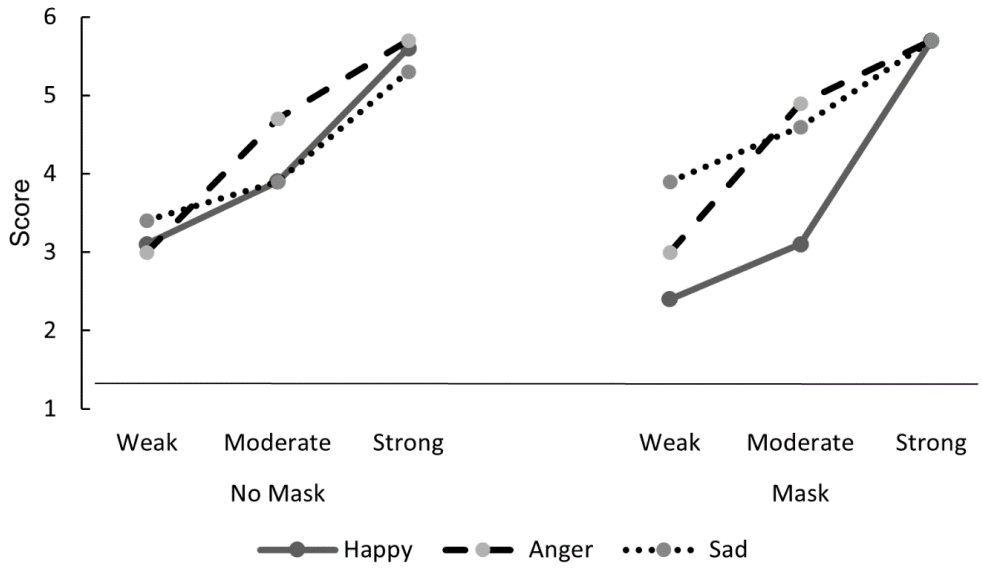

Figure 2. Means of the emotional intensity by the evaluators

3) Procedure

After two types of exercises (Exercises 1 and 2), children completed the experimental task. In Exercise 1, three types of facial expressions (happy, angry, and sad) were presented on a monitor, using simple straight and curved lines to represent eyebrows, eyes, nose, and mouth. The participants were asked, 'Which is the happy/angry/sad face?'

The children were asked to choose one of the three options verbally or by pointing. In Exercise 2, an illustration of a character familiar to young children was presented. The participants were asked, 'What kind of face does this character have?' followed with 'Is it a happy face? Is it an angry face? Is it a sad face?' One finger of the experimenter was raised for each emotion to show three options.

The experiments were conducted individually for each child, with an interval of at least 1 hour between the two task conditions (with or without a mask). The participants were randomly assigned to two conditions to counterbalance the order of presentation: one group first performed the task without masks and the other group first performed the task with masks. In the experimental task, participants were asked, 'What kind of face does this person have?' followed with 'Is it a happy face? Is it an angry face? Is it a sad face?' During the experiment, we did not give feedback as to whether the response was correct but rather repeated the participant's response or praised the participant. Each facial stimulus was presented in color on a 33 × 52 cm monitor. The size of the facial image on the screen was 26 × 17 cm, and the distance from the child's position to the screen was approximately 1 m.

4) Statistical Analysis

We used generalized linear mixed model to investigate the difference in response (correct [1] vs incorrect [0]) by mask, emotion, and intensity of emotion. The mixed model included the fixed effects of mask (no mask = reference category), emotion (happy, anger, and sad; happy = reference category), and intensity of emotion (weak, moderate, and strong; weak = reference category). We included interaction terms for mask and emotion to examine possible difference of effects by facial mask by emotions. Age was included as a covariate. The random intercept for individual participants was included as a random effect. Because the model assuming random slopes did not converge, we did not include the random slopes in the current analysis. Due to a quasi-complete separation (i.e., 100% positive response for all observation in a cell) issue in the current dataset (Figure 3), we used a penalized logistic regression model to obtain better estimates[20]. Statistical analyses were conducted using R software ver. 4.2.2. The odds ratios (OR) and standard errors (SE) were estimated using blme package with binomial family structure. We had no missing observations for the current experiments. The significance threshold was set at $p < .05$.

III. Results

The proportion of correct responses in each stimulus is provided in Figure 3. The global correct response rate was 86%, 88% in the no mask condition, and 83% in the mask condition. In happiness, more than 90% of the participants responded correctly regardless of the mask conditions.

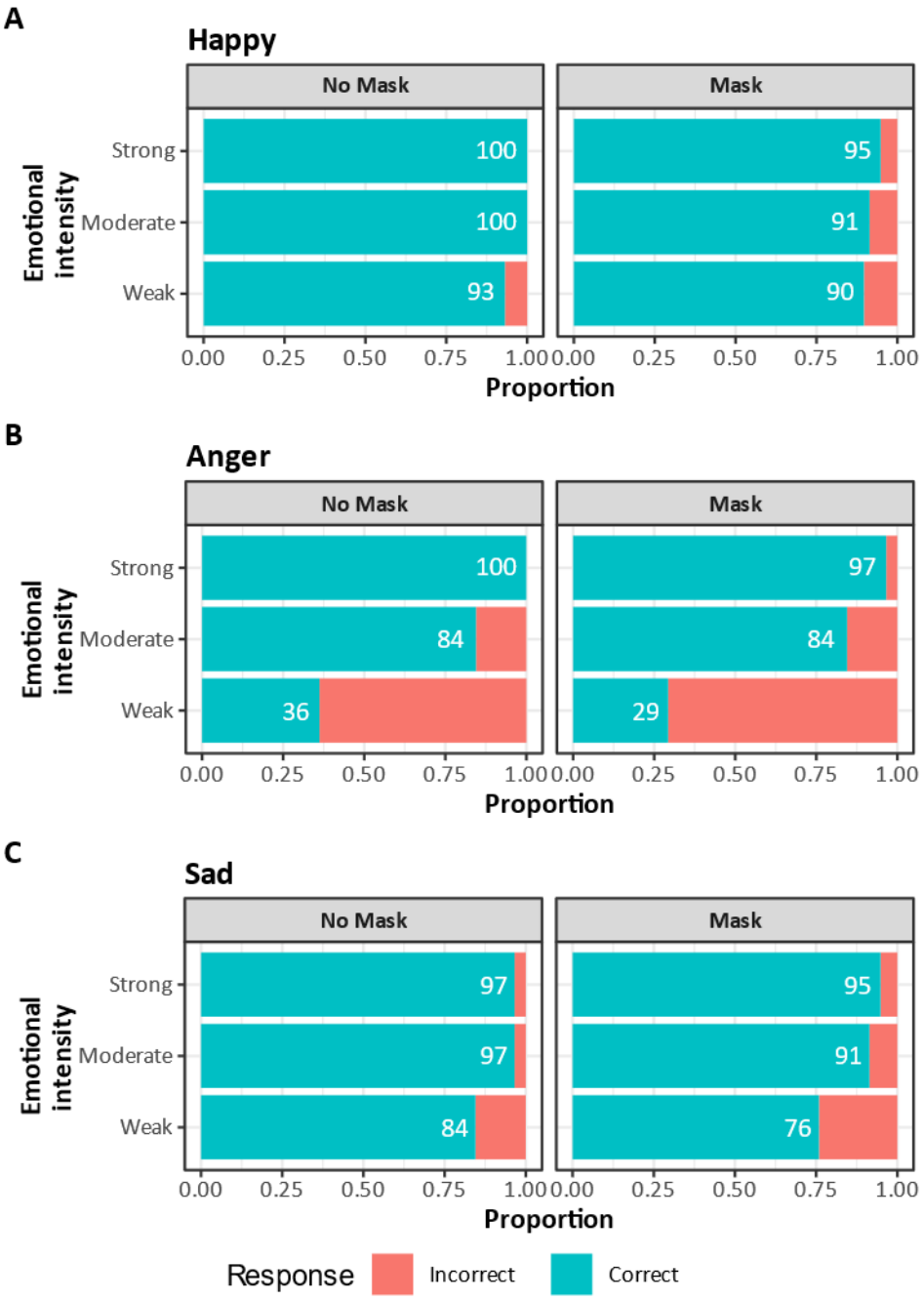

Figure 3. The proportion of correct responses in each stimulus (emotion x emotional intensity). The left side shows the no mask condition, and the right side shows the mask condition. The percentage of correct responses for each stimulus is shown in the bar plot.

The facial mask showed a significant effect on correct response in children ($OR = 0.29$, $SE = 0.16$, $p = 0.021$), which was associated with worse performance (Table 1). Emotion and intensity showed significant effects on correct responses in children. Anger and sad emotions were significantly associated with worse performance in comparison to happy stimuli ($OR = 0.04$, $SE = 0.02$, $p < 0.001$ for anger; $OR = 0.32$, $SE = 0.17$, $p = 0.035$ for sad).

Moderate and strong expressions (intensity) were associated with better performance (*OR* = 8.04, *SE* = 2.13, $p < 0.001$ for moderate expression; *OR* = 29.12, *SE* = 10.95, $p < 0.001$ for strong expression); however, the estimates showed very large margin of errors (Table 1). The effects of the interaction terms were not significant.

Table1. Logistic regression models for correct response to the task

Explanatory variable	*Odds ratio*	*SE*	*95% CI*	*z*	*p*
Mask	0.29	0.16	[0.10, 0.83]	-2.31	0.021
Emotion					
Happy	reference				
Anger	0.04	0.02	[0.02, 0.11]	-6.3	< .001
Sad	0.32	0.17	[0.11, 0.92]	-2.11	0.035
Intensity of emotion					
Weak	reference				
Moderate	8.04	2.13	[4.79, 13.51]	7.88	< .001
Strong	29.12	10.95	[13.94, 60.84]	8.97	< .001
Interaction terms					
Mask × Anger	2.56	1.53	[0.79, 8.27]	1.57	0.116
Mask × Sad	1.59	1.04	[0.44, 5.75]	0.7	0.482

Model fit indices: AIC = 617.4, BIC = 671.9, Deviance = 595.4.

Covariate: Age

SE: standard error

CI: confidence interval

IV. Discussion

1. Mask-wearing and Facial Expression Recognition in Preschool Children

To investigate the effect of wearing a mask on facial expression recognition, we compared the accuracy of facial expression recognition of faces with and without a mask. Mask-wearing reduced the accuracy of facial expression recognition in preschool children.

The global correct response rate was high in no mask (88%) and mask conditions (83%), resulting 5-point decline by wearing a mask in the current sample. A recent study published in 2023 also showed similar results in Japanese preschoolers, i.e., 5-point decline by masking[21]. Although the correct response rate in the previous study was about a little higher than in our study, this may be because the facial expression stimuli used in the previous study were similar to the "Strong" facial expression stimuli used in our study. In fact, the correct response rate of “Strong” facial expression in this study (99% and 96%) was very similar to those in the previous study. A significant decline in accuracy could be attributed to limited information due to the mouth and nose being covered. In

addition, previous studies suggested that facial masks may reduce perceived intensity of emotion and confidence in one's own assessment[12,16,22]. These factors may explain the significant decline in accurate response in children.

While a previous study showed that masks decreased correct responses by 21–25% in children between 3 and 5 years old[13], another study reported more mild effect of the mask (i.e., 4-point decrease) in facial recognition in the same age range[23]. The inconsistency may be explained by a difference in global correct response rate: 57% for Gori et al.[13], 69% for Schneider et al.[23], and 86% for the current study. In addition, these indices may reflect the difficulty of the task stimuli and the number of emotion labels (e.g., 3 vs 5 emotions). The facial mask may affect the accurate recognition of facial expressions that are already difficult to correctly recognise. Another possible factor is the time of the study. Gori et al. conducted the experiments in Italy in May 2020[13], during the early stages of the COVID-19 pandemic. In contrast, Schneider et al. and the current study were conducted in 2021[23], when the use of masks had already become routine practice for infection prevention measures. Therefore, it is highly likely that preschool children were exposed to faces covered by masks daily and experienced the emotional expressions of other people while wearing a mask. This suggests that repeated exposure to a mask-covered face may change the recognition process. Although we cannot directly compare the previous and current results owing to differences in stimuli and study designs, it is possible that this discrepancy is influenced by these factors and a cultural factor. The results suggest that the facial mask partially interferes with accurate perception of facial expression; however, the influences may not be large in preschool children.

In the present study, the proportion of correct recognition of happiness exceeded 90%, regardless of emotional intensity or mask-wearing. Recent studies have shown that 'happy' is more correctly recognised in most preschool children in both with and without mask (87% and 95%, respectively)[23-24]. As children's recognition of happy facial expressions is better than their recognition of angry and sad facial expressions at age 5[25-26], our results are in line with previous findings. Children are more likely to recognise positive emotions such as happiness and value and interpret positive information more often than negative[27]. Such characteristics may explain the higher correct responses in happy face stimuli, although a recent Japanese study did not find the difference by emotions[21].

In addition to emotions, intensity of the emotion may affect the accuracy of the recognition. A recent study of Japanese preschoolers reported high correct response rates, 93% and 98% for with or without mask conditions[21]. The rates were about 10 points higher than those in our study. On the other hand, the correct response rates for "Strong" stimuli in our study were 96% and 99% (averaging three emotions) for each condition, which shows similar proportions. The contribution of our study was to investigate the effects of masking by incorporating the intensity of the emotional expressions, a potential contributing factor to the difficulties in emotion identification in children. Even after

controlling for the emotional intensity of the stimuli, wearing a mask decreased accurate facial expression recognition. The results suggested that more intense expressions were associated with more accurate responses, while a previous study did not report a significant effect on accuracy of emotion recognition in preschool children[13]. Although the intensity of emotion has not been well-investigated in preschool children, mild or subtle expression, that is, more ambiguous expression, may lead to less accurate responses or reduce confidence in their responses[12,22]. To increase accuracy or confidence in estimating emotions, visual and verbal cues[28] may be helpful for preschool children. Given literature have indicated positive associations between emotional knowledge and later language learning and reading achievement[29-30], development of emotional competence is an essential educational goal for preschool teachers[31]. Teachers' knowledge regarding these issues may benefit their educational practice and contribute to facilitating the emotional development of preschool children.

2. Limitations

This study had several limitations. First, because we limited the number of stimuli to three, we could not examine emotions other than those used in this study. Since the task of reading facial expressions from parts of the face has been examined for emotions such as fear, surprise, and disgust[22,32-33], a broader range of emotional characteristics must be clarified. Additionally, a smaller number of choices increases the chance of an accurate response, which may cause difficulties in identifying differences in the recognition of different emotions. Second, the results were obtained by experimental tasks using static facial stimuli (i.e., pictures). Therefore, the task does not directly measure the ability to recognise the facial expression in daily settings, such as dynamic movement in faces and circumstances. This may limit the external validity of the findings. Third, as this study was conducted during the COVID-19 pandemic, when the use of masks was common even among preschool children in Japan, such environmental factors should be considered when interpreting the results.

3. Conclusions

In this study, we investigated the effects of wearing masks on facial expression recognition in Japanese preschool children. The results revealed a small reduction in accuracy for facial expression recognition in masked face stimuli.

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