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ORIGINAL RESEARCH

Own-Age Effects in a Face-Emotion Recognition Intervention for Children With ASD--Evidence From Eye Movements

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Video abstract

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Background: The own-age effect is the phenomenon in which individuals perceive and recognize faces of their own age better than others in terms of cognitive processing. Previous eye movement studies on children with autism spectrum disorders (ASD) have reported that children with ASD have an attentional bias toward own-age faces and own-age scenes.

Methods: The present study used own-age faces as the intervention material and examined the application of the own-age effect in the emotional recognition of faces in ASD. The length of the intervention was 12 weeks, and 2 sessions were conducted each week.

Results: The results revealed that the own-age face intervention group gazed at children's faces significantly more often than before the intervention, gazed at children's angry faces significantly longer than before the intervention, and gazed at adults' happy faces significantly longer and more often than before the intervention; the other-age faces intervention group did not differ significantly from the preintervention in gazing at children's and adults' faces after the intervention.

Conclusion: The results suggest that own-age faces as teaching materials can better promote the emotion recognition ability of children with ASD than other-age faces.

Plain language summary: ASD have difficulties with facial emotion recognition and previous study found that children with ASD correctly identified emotions in own-age faces more often than in other-age faces. Therefore, using pictures of children's faces to intervene in children with ASD is beneficial to improve their facial emotion recognition ability. Previous studies have mostly used questionnaires to assess the effects of peer-matched interventions, and few have used an eye-movement technique that can effectively monitor changes in eye gaze patterns across different emotions.

We found that the own-age face intervention group gazed at children's faces significantly more often than before the intervention, gazed at children's angry faces significantly longer than before the intervention, and gazed at adults' happy faces significantly longer and more often than before the intervention. It indicates that own-age faces as teaching materials can better promote the emotion recognition ability of children with ASD than other-age faces.

The own-age effect can be applied to experimental materials, the attribute settings of intervention materials, and the selection of accompanying objects to further expand the own-age effect in the educational intervention and training of social and cognitive abilities in ASD. It is expected to help autism improve its social skills and better integrate into the society.

Keywords: children with autism spectrum disorders, own-age faces, intervention, eye tracking

Introduction

One of the core symptoms of Autism Spectrum Disorder (ASD), a common neurodevelopmental disorder, is social communication deficits, which are characterized by difficulties forming normal own-age relationships, engaging in reciprocal social behaviors, and responding appropriately to nonverbal cues such as emotional facial expressions.[1]

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Facial emotions convey rich social cues that can help people understand the emotions and intentions of the person expressing them,[2] and recognizing facial expressions is an important social cognitive ability that is related to real-world social behaviors and cognitive abilities.[3]

Behavioral studies have reported that individuals with ASD have difficulties with facial emotion recognition,[4] and the difficulty in processing facial emotions, the more severe their social deficits.[5] The impairment in recognizing facial expressions in children with ASD is present in not only low-functioning individuals with ASD[6] but also high-functioning ASD individuals.[7] There are multiple factors affecting the ability to recognize emotions in individuals with ASD, such as age, intelligence, and imitation ability. A research has found that impairments in emotion recognition in individuals with ASD do not disappear with age and that difficulties with emotion recognition exist from childhood to adulthood.[8] Some researchers have reported that the degree of difficulty in recognizing emotions is positively correlated with the age of individuals with ASD;[9] however, the research concluded that as individuals with ASD age, their ability to recognize emotions increases and that experience and intervention play an important role in the process of increased emotion recognition.[10] In addition to the age factor of individuals with ASD, the age of the recognition subject may also influence their facial emotion recognition.

Research has found that healthy adolescents recognize own-age faces more accurately than other-age faces,[11] a phenomenon known as Own-Age Bias (OAB) whereby knowledge related to faces develops with the experience of spending frequent time together, resulting in individuals being more accurate with own-age faces than with faces of other ages on behavioral tasks of recognition memory and emotion recognition. Eye movement studies on children with ASD have found that children with ASD gaze longer at a single presentation of own-age faces than at other-age faces, and children with ASD show a gaze bias toward own-age faces.[12] There have been research explored the effect of different scene age characteristics on the gaze of children with ASD as a starting point and found that children with ASD preferred to gaze at faces in children's scenes than those in adult scenes.[13] Similar results were found in a facial emotion judgment task, Hauschild found that children with ASD correctly identified emotions in own-age faces more often than in other-age faces. It is evident that own-age faces facilitate the behavior of individuals with ASD in social tasks.[14]

Emotion recognition interventions for individuals with ASD can enable individuals with ASD to better adapt to society and help them improve their autistic symptoms. Williams randomly assigned children with ASD to either an intervention group or a control group.[15] The intervention group watched a video specifically designed to teach emotion recognition skills to children with ASD; it presented adults with different emotional expressions on a car body, and the control group watched only a video of an animated train (named Thomas the Train). It was found that the intervention group showed significant improvement in the recognition of angry expressions only after the intervention, but this improvement did not last until the third month. This seems to indicate that using real adult faces as emotion recognition material for children with ASD is not effective. Huo conducted an intervention study related to the emotion recognition ability of individuals with ASD using cards with real-life facial expressions (both adult and child faces) and dynamic videos as intervention materials and found that the intervention based on pictures of facial expressions improved the recognition of happiness, sadness, anger, and fear in children with ASD.[16] Liu used videos of real faces as intervention materials and rounds of instruction as an intervention method and found that children with ASD achieved good short-term improvement in their emotion recognition abilities.[17] In summary, the intervention based on real-life facial expressions was effective in improving the facial emotion recognition ability of children with ASD. Williams' study found significant intervention effects only on angry expressions. Huo's intervention study had significant intervention effects on all expressions, possibly due to the age difference of the face materials. The instructional videos used by Williams contained only faces of children. Unfortunately, Huo's study did not compare the effects of adult and child faces on children with ASD.

Therefore, the present study used pictures of children's faces and pictures of adults' faces as intervention materials for different groups to intervene in the facial emotion recognition ability of children with ASD. Previous work has mostly used self-administered questionnaires to assess intervention effects, and given that eye movement techniques can effectively monitor changes in eye gaze patterns under different emotions, this study used eye movement techniques to detect the emotion recognition process in children with ASD and examined the application of the own-age effect in emotion recognition in children with ASD by comparing the eye movement indexes before and after the intervention to provide suggestions for facial emotion recognition intervention studies.

This study hypothesized that the own-age face intervention group would recognize facial emotions better than the other-age face intervention group after the intervention, that the own-age face group would be better at noticing pictures of children's emotional faces after the intervention, and that the own-age face intervention group would differ in noticing different types of emotions after the intervention.

Methods

Participants

Twenty-four children with ASD were selected from the same special education school, and all subjects were diagnosed with ASD by a tertiary care hospital. Verbal intelligence was assessed using the Peabody Picture Vocabulary Test (PPVT), and autism was assessed using the Childhood Autism Rating Scale (CARS). There were no significant between-group differences in physical age, verbal intelligence, length of schooling, and instructional comprehension (as assessed by the special education teacher) for each of the 12 children with ASD in the own-age face intervention group and the other-age face intervention group. One subject each in the own-age face group and the other-age face group were removed because they failed to complete the assessment experiment, and the final intervention data for 22 children with ASD were used, as shown in Table 1.

Experimental Design

This study used a mixed-factor design of 2 (group: the own-age face intervention group, other-age face intervention group) × 2 (assessment: preintervention, postintervention) × 2 (face materials: children's pictures, adult picture) × 4 (emotional categories: happy, sad, angry, scared), with intervention group as a between-subjects variable.

Materials

Experimental Materials

The materials were self-photographed pictures of children's and adults' faces. Sixteen children and 16 adults, half of each gender, were recruited, and the average age of the child models was 8.01 years (*SD*=1.06 years), and the average age of the adult models was 20.00 years (*SD*=1.13 years). Excluding obvious features such as jewelry, glasses, and clothing, four emotions were photographed: happy, sad, angry, and scared. The photographs of the models were then posted on the questionnaire website using a seven-point Likert assessment and assessed for the type of emotion and intensity of emotion (1 indicating the weakest and 7 indicating the strongest). After 22 subjects were evaluated, 24 sets of photos that matched the emotion word to a degree of 4 or more were selected as the experimental pictures, each consisting of happy, sad, angry, and scared, and the quadrant positions in which the four target emotions appeared in the pictures had been balanced. All pictures were processed by Adobe Photoshop 2021 with a size of 1650×1080 pixels. The details are shown in Figure 1. Twenty-four groups of pictures were included; 16 groups were used for experimental materials, and 8 groups were used for intervention materials.

Intervention Materials

The intervention materials were eight sets of pictures and eight sets of children's and adults' facial expression materials from the internet. Each set of pictures contained four expressions: happy, sad, angry, and scared. All intervention materials were assessed for the type and intensity of emotion using a seven-point Likert scale, and the mean expression intensity was above 4.

Table 1 Basic Information About Children in the Own-Age Face Intervention Group and the Other-Age Face Intervention Group (*M*±*SD*)

	Own-Age Face Intervention Group (N=11)	Other-Age Face Intervention Group (N=11)	*t*	*p*
Age (years)	10.6±1.2	10.8±1.9	−0.42	0.68
Verbal intelligence scores	16.9±11.4	25.8±18.7	−1.35	0.19
CARS	31.6±4.8	31.7±2.8	0.078	0.94

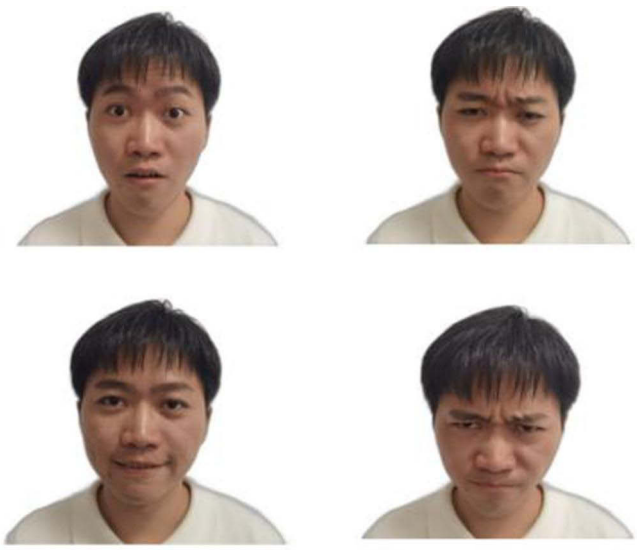

Figure 1 Example diagram of experimental materials.

Procedure

Preintervention Measurement

In this study, an eye movement experiment was conducted to provide a baseline measure of facial emotion recognition ability in the children with ASD before the intervention formally began. The subjects sat at a distance of 60–70 cm from the computer monitor, and the eye tracking device was calibrated at 5 points; the instructions were presented and broadcast to the subjects at the beginning of the experiment, and when the subjects finished the calibration, the experiment began with the target emotion word presented in the center of the screen for 3 s. The instructions were spoken by voice, such as "Please look at the happy picture"; then, the face of each picture conveyed one of four expressions (happy, sad, angry and scared) of a single model with a white background; the experiment contained 16 pictures (4 pictures for practice trials). The experimental materials were photographs of 4 models (1 boy, 1 girl, 1 adult male, and 1 adult female), the emotional face positions were balanced in four quadrants, and the experimental pictures were presented randomly. The specific measurement procedure is shown in Figure 2.

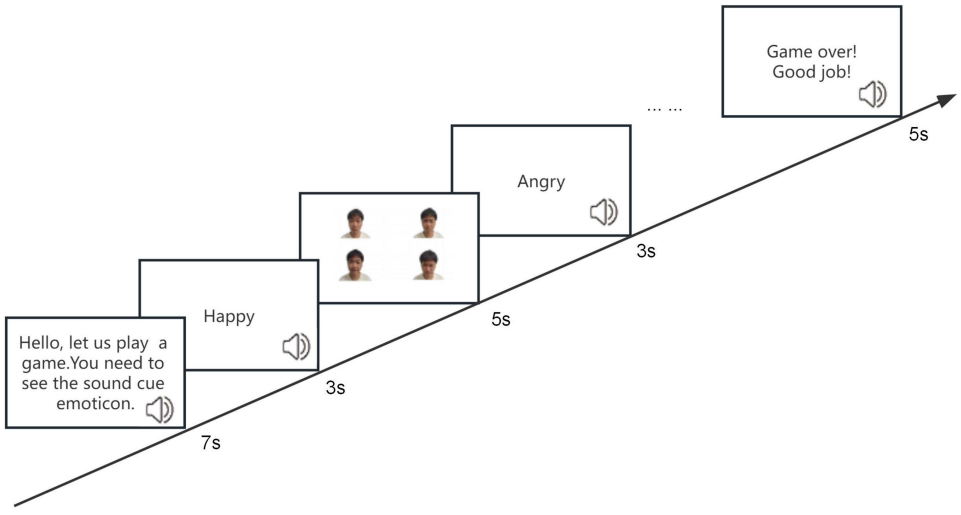

Figure 2 Measurement flow chart.

Intervention Period

The intervention was conducted by the special education teacher in a classroom setting, with two weekly intervention sessions of 30 min each, for a total intervention duration of 12 weeks. In the classroom, Siwo slides were used to present the intervention materials with other-age faces, child faces were used as the intervention materials for the own-age face group, and adult faces were used as the intervention materials for the other-age face group. First, the special education teacher presented the face materials, told the children with ASD what kind of expression this is, and told the characteristics of the expression, such as "This is sad, why? The corners of the mouth are down and tears are flowing." Second, the special education teacher used an interactive task, with tokens as a reward, to invite the children with ASD to come to the podium and point out the face with the appropriate expression according to the teacher's instructions. If the child with ASD identified the face correctly, two tokens were awarded; if the child identified the face incorrectly, one token was awarded. Finally, the special education teacher presented the face material again and explained it to the child with ASD to consolidate the memory effect. This part took approximately 5 min.

Postintervention Measurement

When the 12-week intervention was completed, the experimental assessment was conducted again by the researcher following the process described in Figure 2 to record their postintervention gaze for emotional face recognition.

Experimental Apparatus

An SMI Iview X eye tracking device with a sampling rate of 500 Hz and a Dell monitor screen resolution of 1680×1050 pixels was used.

Data Processing and Analysis

For each face picture, the area of interest (AOI) was drawn, and the subjects' eye movement data were analyzed. In this study, 2 areas of interest were divided: full picture (rectangle) and eye (rectangle), as shown in Figure 3.

The following eye movement indexes were used: (1) dwell time: the sum of gaze time and eye beat time to the area of interest; (2) fixation times: the number of gaze points in the area of interest.

Statistical analyses were performed using SPSS version 21.0.

Firstly, A repeated-measures ANOVA of 2 (assessment: preintervention, postintervention) × 2 (group: own-age face intervention group, other-age face intervention group) × 2 (faces: child picture, adult picture) was used for the whole-map area of interest, the results as shown in Table 2.

Based on the results of the analysis in the first step, no further analysis was performed because there was no significant difference between the before and after effects of the intervention performed in the other-age faces intervention group.

Secondly, Data from the own-age face intervention group were subjected to a 2 (assessment: preintervention, postintervention) × 2 (faces: child picture, adult picture) × 4 (emotion type: happy, sad, angry, scared) repeated-measures ANOVA, the results as shown in Table 3.

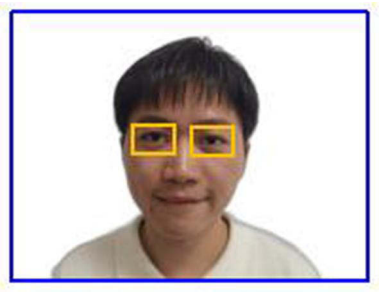

Figure 3 Example map of the area of interest.

Table 2 Gaze on Different Faces in the Own-Age Face Intervention Group and the Other-Age Face Intervention Group (*M*±*SD*)

Fixation Index	Group	Preintervention		Post-Intervention	
		Child Picture	Adult Picture	Child Picture	Adult Picture
Dwell time (ms)	Own-age group	503±329	506±346	732±258	654±369
	Other-age group	637±348	682±321	456±259	571±277
Fixation times	Own-age group	2.4±1.5	2.3±1.3	3.5±1.1	3±1.4
	Other-age group	2.8±1	2.6±1	2.3±0.96	2.8±0.99

Thirdly, A repeated-measures ANOVA of 2 (assessment: preintervention, postintervention) × 2 (group: own-age face intervention group, other-age face intervention group) × 2 (faces: child picture, adult picture) was used for the ocular interest area, as shown in Figure 4.

Results

Whole-Map Eye Movement Index Analysis in Both Group

Dwell Time

The interaction between assessment and group type was borderline significant, $F(1, 19)=4.6$, $p=0.059$, $\eta_p^2=0.31$, and further simple effects analysis revealed that after the intervention, the same age face intervention group gazed at the pictures significantly longer than the other-age face intervention group ($p=0.045$). No other main effects or interactions were significant.

Fixation Times

The interaction between assessment, picture type, and group type was marginally significant, $F(1, 19)=4.2$, $p=0.067$, $\eta_p^2=0.3$, and further simple effects analysis revealed that after the intervention, the own-age face intervention group gazed at children's pictures significantly more often postintervention than preintervention ($p=0.043$) and significantly more often than the other-age face intervention group ($p=0.018$). No other main effects or interactions were significant.

Analysis of Full-Image Eye Movement Indicators for Different Emotional Faces in Own-Age Intervention Group

Dwell Time

The interaction between emotion type, assessment and picture type was marginally significant, $F(1,8) = 3.1$, $p = 0.093$, $\eta_p^2 = 0.53$, and further simple effects analysis revealed that the own-age face intervention group spent significantly more time gazing at angry children after the intervention than before ($p = 0.003$); the own-age face intervention group spent significantly more time gazing at happy adults after the intervention than before ($p = 0.035$). The assessment main effect was significant, $F(1, 8) = 6.6$, $p < 0.05$, $\eta_p^2 = 0.4$, with the own-age face intervention group spending more time gazing at faces after the intervention than before; the picture main effect was significant, $F(1, 8) = 7.1$, $p < 0.05$, $\eta_p^2 = 0.42$, with the own-age face intervention group spending more time gazing at children's pictures than at adults' pictures. No other main effects or interactions were significant.

Fixation Times

The interaction between mood type, assessment, and picture type was marginally significant, $F(1, 8)=3.4$, $p=0.073$, $\eta_p^2=0.56$, and further simple effects analysis revealed that the own-age face intervention group gazed at the happy adult significantly more often after the intervention than before ($p=0.031$); the main effect of intervention expectancy was significant, $F(1, 8)=8.2$, $p<0.05$, $\eta_p^2= 0.45$, and the own-age intervention group gazed at faces more often after than before the intervention ($p=0.04$); no other main effects or interactions were significant.

Table 3 Gaze on Different Expressions in the Same Age Intervention Group (*M*±*SD*)

Fixation Index	Picture type	Happy		Sad		Angry		Scared	
		Preintervention	Postintervention	Preintervention	Postintervention	Preintervention	Postintervention	Preintervention	Postintervention
Dwell time (ms)	Adult picture	359±184	932±696	490±251	505±319	630±257	601±384	501±184	533±313
	Child picture	677±270	872±576	557±194	724±303	400±218	830±281	619±361	660±262
Fixation times	Adult picture	3.1±0.9	3.3±1.7	2.6±1.2	3.3±1.2	2.4±1	3.5±1.5	2.8±1.6	3.2±1.0
	Child picture	2.2±0.9	4.3±2.4	2.7±1.7	2.7±1.5	3.1±1.3	2.8±0.9	2.1±0.9	2.9±1.5

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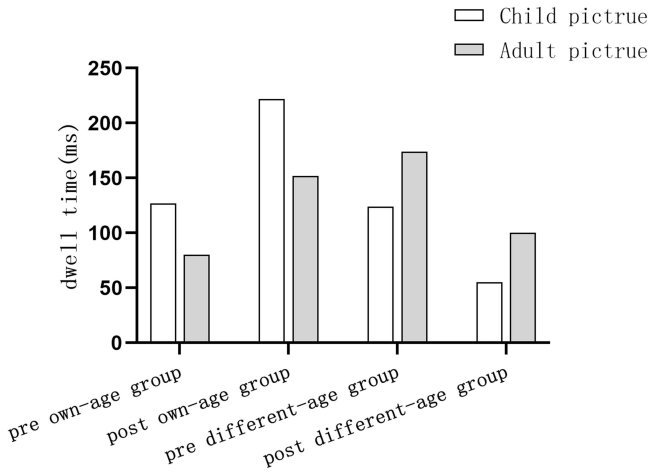

Figure 4 Dwell time on the eyes in the own-age face intervention group and the other-age face intervention group.

Analysis of Eye Area of Interest Indicators in Both Group

Dwell Time

The interaction between assessment and group type was significant, $F(1, 15)=11.3$, $p<0.05$, $\eta_p^2=0.57$, and further simple effects analysis revealed that the own-age face intervention group gazed at the eyes longer after the intervention than before the intervention ($p=0.019$); the own-age face intervention group gazed at the eyes longer after the intervention than the other-age face intervention group ($p=0.006$). No other main effects or interactions were significant.

Fixation Times

The interaction between assessment and group type was significant, $F(1, 15)=5.9$, $p<0.05$, $\eta_p^2=0.43$. Further simple effects analysis revealed that the own-age face intervention group gazed at the eyes more often after the intervention than before ($p=0.008$); the own-age face intervention group gazed at the eyes more often after the intervention than the other-age face intervention group ($p=0.008$). No other main effects or interactions were significant.

Discussion

There is an Own-Age Effect in the Emotion Recognition Intervention for Children With ASD

In the present study, the analysis of eye movement indicators of the full picture revealed that the own-age face intervention group looked longer at pictures after the intervention than before the intervention; the own-age face intervention group looked longer at the children's pictures after the intervention than the other-age face group, which is consistent with the previous findings of Jelili,[18] who used pictures/videos of other-age faces (adolescent faces, children's faces) as experimental material. The results showed that the children with ASD were more accurate in recognizing children's facial emotions than those of adolescents, suggesting that the ASD subjects performed better in recognizing facial emotions in individuals of the same age range. Similarly, a study by Hauschild found that adolescents with ASD were more accurate at recognizing own-age faces than other-age faces.[14]

This study found that the own-age face intervention group showed better eye gaze after the intervention than before the intervention; the own-age face intervention group showed more eye gaze after the intervention than the other-age face intervention group. The eyes are key to communicating social information, but individuals with ASD gaze at the eyes less, which researchers suggest may be because individuals with ASD perceive the eyes as aversive and socially threatening.[19] In a study of children with ASD and TD, Falck-Ytter found that social impairment was negatively associated with the amount of time spent gazing at the eyes.[20] The more severe the social impairment of children with ASD, the shorter the eye gaze time. In contrast, the present study applied the own-age effect to facial emotion recognition

and effectively increased eye gaze on own-age faces in children with ASD, suggesting that the application of the own-age effect may slow eye avoidance in children with ASD, which may decrease the social deficits in children with ASD.

This study found no significant difference between the other-age face intervention group in terms of either face or eye gaze after the intervention and before the intervention, which indicates that the intervention was not effective. The results of the present study differed from those of previous studies that found that interventions based on adult faces were effective in emotion recognition for individuals with ASD, using intervention materials that gradually transitioned from the expressions of parents and the teachers of students with ASD to those of unfamiliar figures.[21] It is possible that familiar faces play a role in emotion recognition. One study using familiar (mother) and unfamiliar emotional faces as experimental materials showed that children with ASD did not differ from the TD children in recognizing familiar faces, but when recognizing unfamiliar faces, children with ASD were significantly less accurate than TD children.[22] In addition, Sun's study had only 1 subject, and the representativeness of his results needs to be further verified.

There Are Differences in Emotion Types for the Effect of Own-Age Faces on Emotion Recognition

This study found an own-age effect in the emotion recognition intervention for children with ASD, but there were differences between emotion types for the own-age effect. There was a significant difference in the own-age face intervention group for angry and happy faces before and after the intervention. However, there was no significant difference in their gaze on sad and scared faces before and after the intervention.

This study found that the own-age face intervention group gazed at children's angry expressions longer after the intervention than before the intervention, possibly because children with ASD had a floor effect on angry faces before the intervention, so the application of the own-age face effect had a more significant change on their gazing at anger. Some researchers have suggested that gaze deviation from angry faces can be an indicator of ASD severity,[23] and individuals with ASD are considered more autistic the more severe their gaze avoidance of anger is.[24] Individuals with ASD have difficulty processing angry expressions, and seeing angry facial expressions is more likely to cause discomfort, which leads to more avoidance. This phenomenon arises, on the one hand, because the expression of angry faces is usually a reaction to a bad event, which can cause individuals with ASD to feel fearful and thus lead to gaze avoidance of angry faces.[25] On the other hand, the individual's understanding of anger is more complex and requires speculation about the mental state and social norms of the angry person,[26] which individuals with ASD do not possess. The present study facilitated the own-age face intervention group's attention to children's anger through the application of the own-age effect, which may indicate that the application of the own-age effect alleviated the degree of autistic symptoms in children with ASD. Leung identified the ability of children with ASD to recognize angry faces as an important area to be strengthened in early training programs.[27]

This study also found that the own-age face intervention group had a better postintervention gaze on happy adult expressions than the preintervention gaze. The intervention material for the own-age face intervention group was pictures of children's faces, and the own-age face intervention group also showed a significant enhancement of happy expressions on adult faces, indicating that the application of the own-age effect was more pronounced and generalized for the enhancement of happy emotions with the intervention. Previous studies have found that individuals with ASD are superior in recognizing happy emotions and have the highest accuracy rate,[28] and their own dominant effect of happy faces may have facilitated the effect of the own-age effect, resulting in the first generalization of happy expressions by children with ASD in the own-age face intervention group.

Limitations and Outlook

The intervention materials in this study were not evaluated by children with ASD, and although this study is a longitudinal study, longer-term effects have not been studied in this study. Future studies should extend the time frame of the study to test the intervention effects at different time points after the intervention to explore whether the intervention effects are longitudinal.

In addition, it should be mentioned that our study found that using own-age faces as intervention materials could effectively improve the facial emotion recognition ability of ASD, but the materials need to be properly used. If excessively

reliance on the faces of peers to intervene may also have some unfavorable effects: such as that ASD may not be prepared to interact with with people of different ages; resulting in reduced social flexibility and inability to adapt to unfamiliar situations in social situations with individuals of different ages; and may also limit other learning opportunities for children with ASD and increase stigmatization.This suggests that the use of the own-age effect should be gradually generalized to different facial ages and different scenarios rather than only using the own-age effect in anything.

The last, the own-age effect can be applied to other core symptom interventions for children with ASD, not only in the area of emotion recognition, such as using own-age pictures/videos, inviting own-age individuals to demonstrate behaviors, etc. The own-age effect can be applied to experimental materials, the attribute settings of intervention materials, and the selection of accompanying objects to further expand the own-age effect in the educational intervention and training of social and cognitive abilities in ASD. It is expected to help autism improve its social skills and better integrate into the society.

Conclusion

The following conclusions can be drawn in this study: first, using own-age faces as intervention materials can effectively improve the facial emotion recognition ability of children with ASD, and the own-age face group showed significant improvement in the number of face gazes, gaze time, gaze time after the intervention, and the gaze on the eyes of faces; second, the effect of using other-age faces as intervention materials was not significant. Third, there were differences in the effects of the own-age faces on emotion recognition by emotion type, and there were significant changes in the recognition of happiness and anger in the own-age face group after the intervention. However the differences in the recognition changes of sadness and fear were not significant.

Data Sharing Statement

The raw data for this study will be made available by the authors, without undue reservation.

Ethics Approval

All methods in the study were carried out in accordance with relevant guidelines and regulations or in accordance with the Declaration of Helsinki.The studies involving human participants were reviewed and approved by Fujian Medical University Biomedical Research Ethics Review Committee (No.3).The participants' legal guardian(s) provided their written informed consent to participate in this study, and all participants provided their oral consent. The person in Figures 1-3 provided written informed consent for the images to be published.

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Author Contributions

All authors made a significant contribution to the work reported, whether that is in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas; took part in drafting, revising or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

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Disclosure

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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