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Deficits in facial emotion recognition and implicit attitudes toward emotion among adolescents with high functioning autism spectrum disorder

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ABSTRACT

Objective: Impaired social interaction is one of the core characteristics of autism spectrum disorder (ASD). This study was conducted to compare the facial emotion recognition (FER) abilities and emotional interference of adolescents with and without high-functioning ASD by performing the FER Task (FERT) using the faces of Taiwanese people and the Implicit Association Test (IAT), respectively.

Methods: This study recruited 71 adolescents with high-functioning ASD who aged at 11 to 18 years old as the ASD group and 63 adolescents without ASD from the Taiwanese community as the non-ASD group. We investigated FER abilities by conducting the FERT on six types of emotional expression with a three-level intensity rating, and we performed the IAT for evaluating the strength of a person's automatic association with mental representations of emotions in memory.

Results: Compared with the non-ASD group, the ASD group performed significantly worse on facial emotion differentiation and the ranking and rating of emotional intensity in the FERT. The ASD group had higher IAT scores than the non-ASD group.

Conclusion: The results suggest that adolescents with high-functioning ASD have subtle deficits in facial emotion processing and emotional interference.

1. Introduction

Impaired social interaction and communication is one of the core symptoms of autism spectrum disorder (ASD) [1]. One explanation for these impairments in emotional perception and understanding in people with ASD relates to their deficiency in social motivation [2]. Facial emotion recognition (FER) is the process of identifying facial expressions and is one of the important elements of social interaction [3]. The six basic facial emotions are as follows: happiness, sadness, disgust, fear, anger, and surprise [4]. Most children develop the ability of social emotion recognition before the age of 2 years, which gradually matures with age. Near 5 years of age, most children can recognize the facial emotions of happiness and sadness; people become more capable of reading clues from others' facial expressions and understanding complex facial expressions as they age [5,6]. Children who experience difficulties in accurately recognizing facial expressions can face problems in social interactions [3].

Kennedy and Adolphs [7] had reported that social deficits of ASD could result from difficulties in FER. Studies have revealed that individuals with ASD could have FER deficits such as (1) difficulties in recognizing negative facial expressions, namely sadness [8] and fear [9]; (2) difficulties in recognizing complex facial expressions, namely boredom, worry, shame and disappointment [10,11]; (3) discordance between emotions and facial expressions [12]; (4) a short duration of facial expressions [13]; and (5) artificial facial expressions [14].

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Individuals with high-functioning ASD recognize facial expressions by focusing on the lower half of the face rather than the eyes [15]. Eack et al. [16] observed that individuals with ASD frequently misinterpreted happy faces as neutral and over attributed negative emotions to neutral expressions in the Mayer–Salovey–Caruso Emotional Intelligence Test.

In the past, the emotional images used in FER research tools for studying ASD have been primarily composed of high-intensity facial emotions. Recently, researchers have also begun testing participants on sequences of low- to high-intensity emotional facial stimuli. These stimuli can be used to measure not only accuracy but also the degree of intensity required for accurate recognition of facial emotions [17]. Bal and colleagues (2010), using neutral to expressive morphs, found diminished perceptual sensitivity across emotions, which was correlated with social impairment [18]. A recent study by Wingenbach et al. [19] investigated low-, intermediate-, and high-intensity facial emotions. The results indicated that compared to controls, the ASD group showed significantly more confusion between emotional categories at high intensity, and significantly more confusion of emotions as "neutral" at low intensity. Most studies that have focused on the intensity of facial emotions have had a small sample size; thus, a larger sample size and population are required to obtain a thorough understanding of the relationship between people with ASD and facial emotions. In addition, people without ASD have different behavioral reactions to interpretations of different emotional intensities; for instance, when children perceive parents to be slightly or highly angry, this influences whether they amend their incorrect behavior. Therefore, the ability to correctly distinguish facial emotion intensity is a crucial topic in social interaction.

Previous studies on FER in people with ASD have several limitations. First, some studies only labeled various emotions but did not measure emotional intensity. Moreover, studies have proposed that impaired emotion recognition in ASD is higher for highly subtle emotional expressions [3,20,21]. A recent study did not support the supposition that impairments in FER accuracy are limited solely to low-intensity expressions [22]; however, further study is required to examine the recognition of facial expressions from morph sequences with variable emotional intensities [22]. Second, in relevant studies, the FER of Chinese people with ASD has been analyzed using images of Caucasian people. Moreover, the evaluation of FER in Chinese participants using faces of Caucasian people may increase study bias through unfamiliarity. Third, some studies had small sample sizes [8,23].

FER can be processed implicitly and automatically by association processes [24]. West et al. [25] also illustrates that individuals with ASD show differences from controls in the effects that speech processing (of semantic and prosodic cues) have on the recognition of facial emotion. This is important to note as a study of facial emotion processing that relies on visual presentation alone does not necessarily provide a realistic emulation of processing of facial emotion in more complex real-world scenarios. Otherwise, human communications are not always congruent between facial expressions and their feelings. Emotional interference may be elicited by association processes in the presence of incongruent emotional cues. Studies have demonstrated abnormal emotional interference in people with mental illnesses [26–28]. For instance, people with schizophrenia and mood disorder respond more intensely to disease-related words, and people with obsessive-compulsive disorder (OCD) selectively attend to threatening stimuli associated with their OC concern. However, little is known about whether emotional interferences during emotional recognition in individuals with ASD are different from those in individuals without ASD. A study revealed that children with autism appeared to ignore or not notice negative emotions in adults [29]. However responses to different emotions in individuals with ASD require further examination. Emotional interference during FER can be evaluated using the modified protocol of the Implicit Association Test (IAT) [30]. Greenwald et al. [31] indicated that the IAT could reveal associative information that people were either unwilling or unable to report, such as esteem, perception, and personality. Until now, the IAT has not been used to examine emotional interference during emotional recognition in individuals with ASD. This study employed primarily the IAT to compare individuals with and without ASD and reveal whether differences exist in their connections with emotional images and positive or negative words. In the IAT, a shorter time for the congruent (e.g., a positive word with positive emotional image) trial indicated a stronger connection between words and images; a longer time for the incongruent (e.g., a negative word with positive emotional image) trial indicated that words more severely interfered with the emotional images. Generally, a shorter congruent time and longer incongruent time indicated a stronger connection between words and images.

The present study aimed to examine the differences between adolescents with and without high-functioning ASD in terms of their FER abilities and emotional interference by using the Facial Emotion Recognition Task (FERT) and IAT, respectively. Dyck et al. [32] reported that cognitive functions and age may influence the FER abilities of children with ASD; therefore, we adjusted for the effects of intelligence and age while examining the differences in FER abilities and emotional responses. We hypothesized that adolescents with high-functioning ASD have lower correct rates and longer reaction times in the FERT. In addition, we hypothesized that adolescents with high-functioning ASD have more intense connections to the positive or negative feelings associated with emotional images than individuals without ASD.

2. Methods

2.1. Participants

Individuals with high-functioning ASD from the child psychiatry outpatient clinic of a teaching hospital in Southern Taiwan were enrolled in the ASD group. Those in the ASD group were diagnosed by a certified child and adolescent psychiatrist according to the DSM-5 diagnostic interview. All participants were subjected to an IQ test conducted by a clinical psychologist. The inclusion criteria of the present study were as follows: (1) having an age of 11–18 years; (2) having a diagnosis of ASD according to the fifth edition of the Diagnostic and Statistical Manual of Mental Disorders [1]; (3) having a full-scale intelligence quotient (FSIQ) score, determined by using the Chinese version of the Wechsler Intelligence Scale for Children, fourth edition (WISC-IV) [33], of 70 or higher; and (4) having verbal communication ability. Individuals who had severe comorbid physical problems, had a history of severe brain injury or substance abuse, were comorbid with other severe psychiatric disorders, or were uncooperative to complete all evaluations were excluded. A total of 76 participants were recruited in the study initially; 4 could not finish all the tasks, and 1 could not complete the test in the designated time. Finally, 71 participants were included in the study.

Adolescents without ASD (the non-ASD group) were recruited through online advertising. The inclusion criteria were as follows: (1) having an age of 11–18 years; (2) having no ASD or major psychiatric diseases; and (3) having an FSIQ score of 70 or higher. Adolescents who had severe comorbid physical problems, had a history of severe brain injury or substance abuse, or were uncooperative to complete all evaluations were excluded. The non-ASD group comprised 68 participants, 3 of whom could not complete the test in the designated time, 1 of whom had a family history of ASD, and 1 of whom did not finish the test. Finally, 63 participants remained.

2.2. Measures

2.2.1. Emotional images

The emotional images used as testing tools were primarily derived from a Taiwanese college-student database of facial expression for basic emotions. The images were evaluated by 84 participants, and the results of the evaluation were further classified according to the categories of intensity and emotion [34]. The present study selected pictures with higher consistency and different intensities for use as the following testing tools.

2.2.2. Facial emotion recognition Task (Fig. 1)

The Facial Emotion Recognition Task (FERT) consisted of 70 pictures of Taiwanese people depicting six categories of basic emotion (happiness, sadness, disgust, fear, anger, and surprise) and neutral emotion [34]; intensities of 30%, 60%, and 90% were selected. A total of 70 pictures were used; 38 were pictures representing the facial expressions of women, and 32 depicted the facial expressions of men. In the current study, the FERT was programmed into a computerized test tool by using *E*-prime software. The FERT was administered in three parts. In the first part (FERT differentiation, FERT 1) of the FERT, participants were shown one randomly selected picture from 70 pictures and were then asked to push a button as soon as possible to select the most appropriate emotion displayed. We attached stickers with facial expression descriptions to the numbered buttons; different numbers represented different facial expressions (e.g., happiness = 7, sadness = 8). Participants could read the descriptions and respond by pressing the buttons. The picture was shown for a maximum of 5 s. The screen would shift to the next picture in the absence of any response within 5 s. The computer recorded the reaction times and correct rates of 20 pictures with different intensities randomly selected during FERT1. In the second part (FERT ranking, FERT 2), three pictures showing the same category of emotion with different intensities (30%, 60%, and 90%) were displayed simultaneously on the screen. In FERT 2, the computer randomly selected 10 groups of pictures out of 12 groups for the experiment before the participants sequenced the pictures in order of emotional intensity by selecting either 30%, 60%, or 90% intensity within 10 s (e.g., 312). Ten groups of pictures were shown, and each correct rate was recorded. In the third part (FERT rating, FERT 3) of the FERT, of the 70 pictures, 10 were selected randomly by the computer, and participants were requested to rate the emotional intensities represented in the pictures from 0 (neutral) to 3 (strongest intensity) by pressing the corresponding buttons 0–3. The screen shifted to the next picture in the absence of a response within 5 s. The reaction times and correct rates were recorded by the computer. The total test duration of the FERT lasted approximately 20–30 min.

2.2.3. Computerized Implicit Association Test (Figs. 2 and 3)

The Computerized Implicit Association Test (IAT) was used for emotion recognition under interference effects that were produced by the double categorization of valences and stimulus. We followed the algorithm designed in a previous study [31]. A total of 10 words represented positive meaning (e.g., peace, contentment, rich, tender, and success) and 10 words represented negative meaning (e.g., war, greedy, poverty, and failure), and they were accompanied by pictures showing positive (happiness) and negative (e.g., sadness, disgust, fear, and anger) emotions. The emotional pictures for the IAT in this study comprised 10 pictures of positive emotions (5 pictures of men and 5 of women) and 10 pictures of negative emotions (5 pictures of men and 5 of women). Participants were required to click on left or right mouse button according to positive emotion or words shown in the center of the pictures (according to the information on the upper-left or upper-right corner of the screen). The IAT procedure consisted of five steps. The initial step involved associated attribution discrimination, in which the words were categorized as positive or negative according to their meanings. In the second step, target–concept discrimination was implemented to distinguish between the pictures recognized as showing positive or negative emotions. After emotional attribution discrimination and target–concept discrimination, the words and pictures were superimposed (pairing of positive emotion words with positive emotional pictures) in the third step, in which stimuli for target discrimination occurred in alternative trials. In the fourth step, participants underwent a reversal of response assignment for target discrimination. The final step combined emotional attribution discrimination (without changes in response assignment) with reversal target discrimination. Except for the final step that included 48 trials, each of the other steps had 24 trials. Steps 1, 2, and 4 were practice steps to familiarize participants with the required responses (i.e., left-clicking or right-clicking) upon seeing pictures of facial expressions or text descriptions. Finally, the results of steps 3 (congruent pairings) (Fig. 2) and 5 (incongruent pairings) (Fig. 3) were analyzed. The reaction time of congruent (step 3) or incongruent (step 5) pairings provided the indices of the relative association strength [35]. IAT scores were calculated by dividing the reaction time intervals of congruent and incongruent pairings by the standard deviation of all correct reaction times, according to the D-measure algorithm suggested by Greenwald et al. [31]. A higher IAT score represents a more severe deficit in emotional interference (stronger connectivity between an expression and the feelings associated with words).

2.2.4. Chinese version of the Wechsler Intelligence Scale for Children, fourth edition (WISC-IV)

The WISC-IV is an individually administered intelligence test [36], and its Chinese version has been used with good validity and reliability [33]. The present study used FSIQ on the WISC-IV to represent participants' general intellectual ability.

2.3. Procedure and statistical analysis

Research assistants explained the purpose, procedure, and privacy policy of this study to all participants. All adolescents and one of their

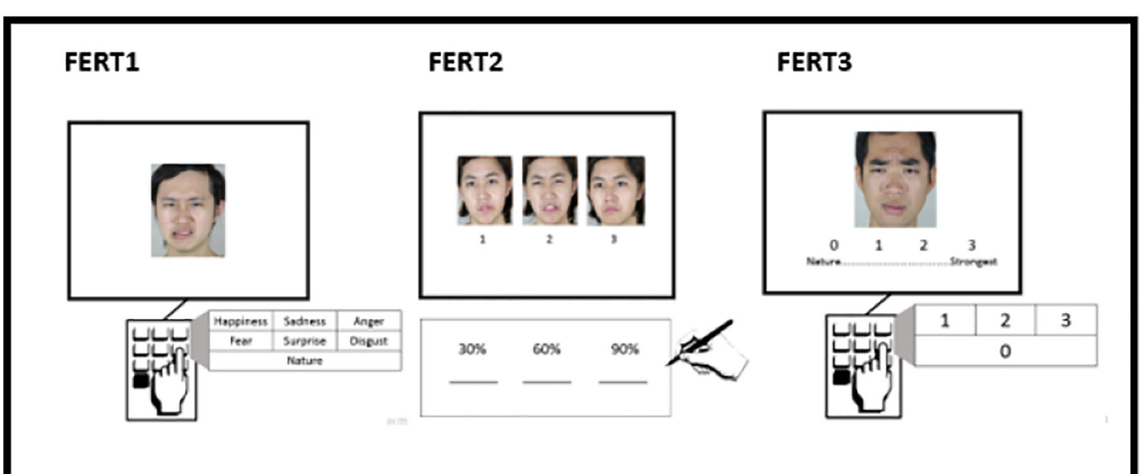

Fig. 1. The Facial Emotion Recognition Task (FERT).

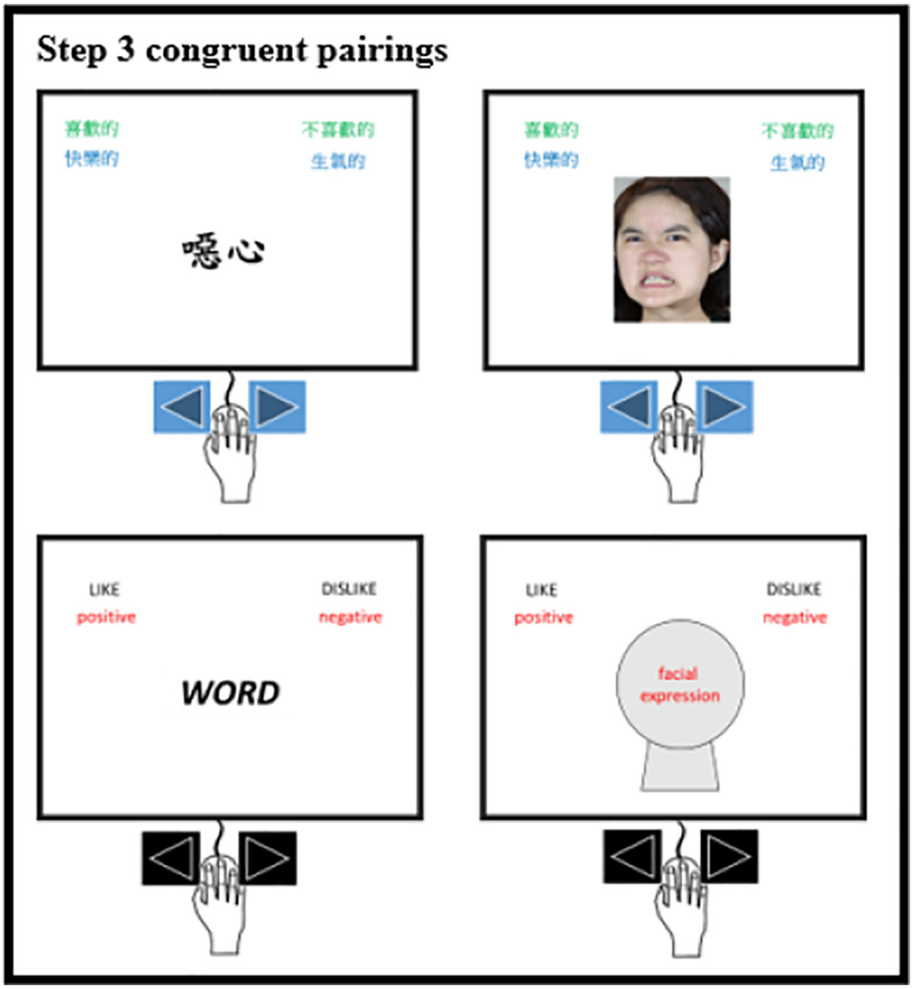

Fig. 2. The Computerized Implicit Association Test (IAT) - step 3.

parents provided informed consent, and all participants were requested to complete the computerized tasks. All participants received NT$300 (approximately US$10) at the end of the assessment.

Data analysis was performed using SPSS 19.0 statistical software (SPSS Inc., Chicago, IL, USA). Differences in age, sex, FSIQ scores, FER, and emotional responses between the ASD and non-ASD groups were examined through the chi-squared test and *t*-test. The associations of the groups (ASD vs. non-ASD), age, sex, and FSIQ scores with FER and emotional responses were examined through multiple regression analysis. A two-tailed p value of $<.05$ was considered statistically significant.

3. Results

Table 1 presents the age, sex, FSIQ scores, FER, and emotional responses of the ASD and non-ASD groups. The results indicated that compared with those in the non-ASD group, participants in the ASD group were older ($p = .001$); had lower FSIQ scores ($p < .001$); had lower correct rates on FERT 1 ($p = .001$), FERT 2 ($p = .003$), and FERT 3 ($p < .001$); and had longer reaction times in FERT 1 ($p = .020$) and on congruent ($p < .001$) and incongruent ($p < .001$) pairings in the IAT task.

Table 2 shows the results of the multiple regression analysis on the association of the groups (ASD vs. non-ASD), age, sex, and FSIQ scores with FER and emotional responses. The results indicated that after adjusting for age, sex, and FSIQ scores, the ASD group had a lower rate of correct responses in FERT 1 ($t = 2.220$, $p = .028$), FERT 2 ($t = 2.752$, $p = .007$), and FERT 3 ($t = 3.409$, $p = .001$), in addition to having a longer reaction time on FERT 1 ($t = -2.325$, $p = .022$), compared with the non-ASD group. In addition, the ASD group had higher IAT scores than the non-ASD group ($t = 2.049$, $p = .043$) (Table 2).

4. Discussion

The present study obtained several important findings. First, the results of FERT 1 for facial emotion differentiation reveal that the ASD group had lower correct rates and longer reaction times than the non-ASD group after adjustment for sex, age, and intelligence. The findings indicate that adolescents with high-functioning ASD had difficulties in accurately differentiating facial emotions, which is consistent with the results of previous studies. For example, Loth et al. [37] indicated that majority of people with ASD have severe expression recognition deficits; Eack et al. [16] observed that people with autism tended to misinterpret positive emotions as neutral and over attribute neutral expressions as negative, compared with healthy participants. Han et al. [38] revealed that people with ASD experience lower activation of the fusiform gyrus in response to facial emotions than healthy participants. Fusiform regions are critical in encoding face traits and identity and are also sensitive to the emotional significance of faces [39]. Impairments in accurate facial emotion differentiation may not only increase difficulties in social interactions for people with ASD [7] but also increase the possibility of exposure to bullying in youths [40].

Second, the results of FERT 2 and FERT 3 reveal that the ASD group had lower correct rates than the non-ASD group, indicating that adolescents with high-functioning ASD had difficulties in ranking and rating the intensity of facial emotions accurately. The possible explanation is that the non-ASD group recognized the intensity of facial emotions

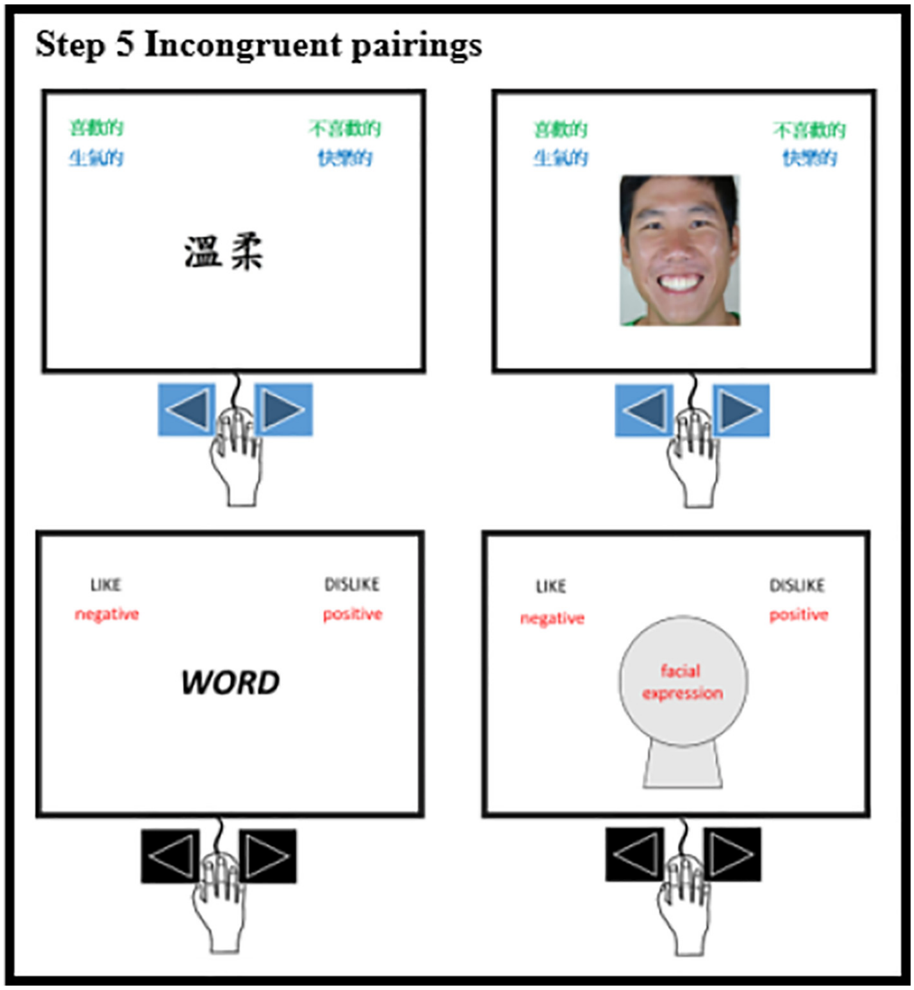

Fig. 3. The Computerized Implicit Association Test (IAT) - step 5.

Table 1
Comparisons of demographic data, intelligence, FERT correct rates, and IAT reactions times between ASD and non-ASD groups.

	ASD (n = 71)		Non-ASD (n = 63)			
	n (%)	Mean ± SD	n (%)	Mean ± SD	*t*	p
Gender					χ^2	
Female	6 (9)		5 (8)		0.012	.914
Male	65 (91)		58 (92)			
Age (years)		14.37 ± 2.21		13.05 ± 2.14	3.495	.001
FSIQ		93.49 ± 14.67		105.46 ± 13.42	−4.779	<.001
FERT 1 correct rate (%)[a]		73.57 ± 13.80		79.74 ± 7.10	−3.306	.001
FERT 1 reaction time (second)[a]		2.21 ± 0.66		1.98 ± 0.48	2.346	.020
FERT 2 correct rate (%)[b]		78.74 ± 17.95		86.28 ± 9.13	−3.066	.003
FERT 3 correct rate (%)[c]		42.13 ± 20.92		55.56 ± 21.36	−3.673	<.001
FERT 3 reaction time (second)[c]		1.87 ± 0.40		1.77 ± 0.50	1.249	.214
IAT correct rate (%)						
Congruent pairing[d]		96.25 ± 6.84		97.48 ± 2.08	−1.442	.153
Incongruent pairing[e]		88.82 ± 9.81		90.77 ± 7.20	−1.299	.196
IAT reaction time (second)						
Congruent pairing[d]		1.00 ± 0.27		0.79 ± 0.17	5.27	<.001
Incongruent pairing[e]		1.99 ± 0.73		1.53 ± 0.48	4.36	<.001
IAT score[f]		0.68 ± 0.37		0.61 ± 0.39	−1.11	.271

FERT: Facial Emotion Recognition Test; FSIQ: full-scale intelligence quotient; IAT: Implicit Association Test.
[a] FERT 1: differentiation of facial emotions.
[b] FERT 2: ranking intensity of facial emotions.
[c] FERT 3: rating intensity of facial emotions.
[d] Congruent pairing: positive emotion pictures paired with pleasant words or negative emotion pictures paired with unpleasant words.
[e] Incongruent pairing: positive emotion pictures paired with unpleasant words or negative emotion pictures paired with pleasant words.
[f] IAT score: (Average reaction time for incongruent pairing-average reaction time for congruent pairing)/standard deviation of all correct reaction times.

Table 2
Differences in FERT correct rates and IAT reaction times between ASD and non-ASD groups after adjustment for sex, age, and FSIQ scores.

	FERT 1 correct rate[a]		FERT 1 reaction time[a]		FERT 2 correct rate[b]		FERT 3 correct rate[c]		FERT 3 reaction time[c]		IAT score[d]	
	Beta	*t*	Beta	*t*	Beta	*t*	Beta	*t*	Beta	*t*	Beta	*t*
Group	0.216	2.220*	−0.227	−0.2.325*	0.281	2.752**	0.329	3.409**	−0.165	−1.650	0.197	2.049*
Gender	0.008	0.089	0.051	0.582	−0.018	−0.204	−0.031	−0.359	0.054	0.595	0.056	0.644
Age	0.014	0.154	−0.121	−1.309	−0.008	−0.081	0.002	0.024	−0.004	−0.044	−0.076	−0.837
FSIQ	0.137	1.442	−0.085	−0.885	0.044	0.446	−0.047	−0.496	0.103	1.046	−0.326	−3.476**

FERT: Facial Emotion Recognition test; FSIQ: full-scale intelligence quotient; IAT: Implicit Association Test.
[a] FERT 1: differentiation of facial emotions.
[b] FERT 2: ranking intensity of facial emotions.
[c] FERT 3: rating intensity of facial emotions.
[d] IAT score: (Average reaction time for incongruent pairing-average reaction time for congruent pairing)/standard deviation of all correct reaction times.
* $p < .05$.
** $p < .01$.

according to detailed face features, namely the eyebrows, eyes, mouth, and depth of facial lines, whereas the ASD group might recognize facial expressions by focusing on only a part of the face such as the lower half of the face [10], which may result in inference errors. Furthermore, a study suggested that people with ASD may use compensatory cognitive strategies rather than automatic affective processing to recognize facial expressions [14]. These compensatory strategies may be ineffective for high-demand tasks such as the recognition of subtle emotional expressions [3,20,21]. However, whether different emotional intensities increase the probability of misinterpretation of various facial emotions by adolescents with high-functioning ASD warrants further investigation.

Our study showed that individuals with high-functioning ASD had more emotional difficulties during emotional shifts and exhibited more intense connections to the positive or negative feelings of emotional images than individuals without ASD, because they had higher IAT scores than those without ASD. The results indicate that individuals with high-functioning ASD had deficits in emotional interference, which were elicited by the implicit contextual association of categories with incongruent emotional valences. The integration of emotional valences from facial expressions and sematic information is essential to resolving emotional interference [41]. Therefore, integration impairments may be triggered by the impairment of emotional binding processes, inability to manage interference effects in incongruent emotional cues, or a combination of both factors [41].

Past imaging studies related to ASD may partially explain this result. Neuroimaging studies have shown dysfunction of the orbitofrontal cortex, anterior cingulate cortex, and caudate nucleus in individuals with ASD [42,43]. The orbitofrontal cortex and anterior cingulate cortex are activated by stimuli with emotional content. A recent study also found that functional connectivity decreases at the network circuit level in autism, involving the orbitofrontal cortex, anterior cingulate cortex, middle temporal gyrus cortex, and the precuneus; these are implicated in emotion and facial processing [43].

4.1. Limitations

Although we adjusted for age, sex, and intelligence, in addition to using faces of the Taiwanese population, the present study has some limitations that should be addressed. First, ASD was diagnosed in this study by using the DSM-5. However, no quantitative data on the severity of ASD were presented. Second, individuals with ASD might have different verbal and nonverbal IQ results, potentially affecting their performance. Third, the recognition of and reaction to facial emotion perceptions in the brain are very complex processes, and emotional processing can affect brain systems that are responsible for face recognition and memory [39,44]. Therefore, the estimation of the actual situation by using the results of a single study and emotional pictures was difficult. Fourth, the control group was recruited using advertisements. Although those with major diseases were excluded when possible, there may have still been errors made in selecting samples, which could not fully represent the general population. Fifth, this study used an IAT task as a tool for assessing emotional interference. The objective was to examine whether an ASD group and control group displayed differences in connections with emotional images and positive or negative words. However, IAT results are easily influenced because individuals with ASD often exhibit executive function deficits, particularly in set-shifting. Therefore, the results of this study can only provide a preliminary understanding of how the ASD group perceived emotions. To understand how those with ASD perceive the connection between emotions and words, an IAT task without emotional interference features would need to be used as a comparison.

5. Conclusions

The results of this study suggest that adolescents with high-functioning ASD have subtle deficits in facial emotion processing and emotional interference. This result indicates that individuals with ASD, in addition to exhibiting errors in expression recognition, make stronger positive or negative emotional connections with expressions than individuals without ASD. The FERT and IAT results reported here support the idea that difficulties in social interactions for individuals with high-functioning ASD can be explained, in part at least, by a general impairment in the integration of facial emotions and context. The present results indicate that the enhancement of accurate FER abilities is important in individuals with high-functioning ASD. The results of this study may provide information for those developing social cognition training programs for adolescents with ASD. To obtain a deeper understanding of the link between emotional perceptions and FER, further research is required.

Conflicts of interest statements

All authors declared no conflicts of interest.

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