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Attention–Attitude Coupling in Implicit Bias toward Individuals Autism: Evidence from Eye-tracking and Implicit Association Test

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Abstract: *Autism spectrum disorder (ASD) is a neurodevelopmental condition. Individuals with autism are facing both overt discrimination and subtle implicit biases that restrict their access to employment, educational opportunities, and social inclusion. This study investigated people's implicit attitudes and visual attentional biases toward autistic individuals by integrating the Implicit Association Test (IAT) with an eye-tracking dot-probe paradigm. Twenty-one participants' viewing patterns were recorded by an eye-tracker while observing images of autistic individuals and neurotypical individuals. A dot-probe task was conducted afterwards. The participants also completed IAT tasks pairing the same images with positive or negative words. Eye-tracking parameters, including total fixation duration (TFD), first fixation duration (FFD), fixation count (FC), and time to first fixation (TFF), were analyzed. IAT performance was assessed using D-scores. IAT Results revealed significant negative implicit biases toward autistic individuals. Male participants exhibited stronger biases than females. There was no significant difference found between autistic and neurotypical faces for TFD, FC, or FFD. While, images of autistic individuals attracted significantly shorter TFF. Moreover, participants displayed shorter TFF for ipsilateral detection points in the dot-probe task. It suggests the presence of early attentional biases. By combining eye-tracking, dot-probe paradigms, and IAT measures, this study demonstrates a link between early attentional biases and negative implicit attitudes. The findings provide behavioral evidences for the attention-attitude dual-stage model. These results highlight the importance of interventions aimed at mitigating bias towards individuals with autism.*

Keywords: *Autism spectrum disorder, IAT paradigm, Reaction time, Implicit bias, Eye-tracking, Dot-probe task*

1. Introduction

Autism spectrum disorder (ASD) is a comparatively common neurodevelopmental condition affecting approximately 1 in 100 children worldwide[1]. This number is even higher in regions taking more active diagnoses. For instance, about 3.2% of children in the United States are diagnosed with ASD[2]. As the ASD population continues to grow, the social challenges faced by individuals on the spectrum have become increasingly significant. Though people's awareness of ASD has improved over the years, research indicates that autistic individuals still encounter both overt discrimination and covert biases across many areas of life[3]. For example, autistic students are more likely to experience bullying and negative social interactions at school[4] . Meanwhile, only 14–37% of autistic adults are employed. The rate is much lower than that of other disability groups[5][6]. Such pervasive biases also adversely affect their health conditions. As autistic individuals often face reduced access to quality healthcare due to prejudice and misconceptions[7]. Beyond explicit bias, implicit bias further undermine the needs and quality of life for many individuals with ASD[8]. These facts indicate that, in addition to the core challenges of autism itself, societal attitudes and biases play a crucial role in shaping the life outcomes of individuals with ASD.

Implicit measurement techniques such as the Implicit Association Test (IAT) are commonly used in social science and psychology to investigate biases. IAT assesses automatic attitudinal preferences through reaction-time-based categorization tasks. Many studies utilizing IAT have demonstrated clear covert biases against people with disabilities. For instance, approximately 76% of participants in one large-scale social research exhibited a covert preference for non-disabled individuals[9]. Even when individuals explicitly report positive attitudes toward disabled groups, IAT results often reveal underlying negative associations. The IAT effectively captures automatic evaluative associations with social groups or concepts without relying on self-report. It could minimize contamination from social desirability and

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conscious control. Moreover, it has demonstrated strong validity and test–retest reliability[10].

However, the IAT primarily measures the outcome of implicit stereotyping processes and captures cognitive activity during the semantic–response integration phase which typically occurrs more than 600 milliseconds after stimulus onset. Consequently, it cannot reveal the early-stage mechanisms through which stereotypes are triggered and maintained. To address this limitation, the present study incorporates eye-tracking technology, which records gaze behavior with millisecond-level temporal precision. Eye-tracking enables the direct observation of the dynamic trajectory of exogenous attentional capture. Gazing behaviors could reveal individuals' inner activities which is minimally influenced by conscious control[11]. By shifting the analytical focus from the semantic integration stage to the exogenous attention stage, eye-tracking provides a fine-grained temporal window into the early automatic processing of implicit stereotypes. This approach complements the IAT by offering behavioral evidence on the antecedent attentional mechanisms underlying implicit social bias. The results of this study could offer valuable insights for future research on social bias. They may also provide updated evidence regarding public attitude towards individuals with autism, thereby making contributions to reduce discrimination and promote social inclusion.

2. Method

2.1 Participants

Twenty-one participants (M_{age} = 23.71), including 13 females and 8 males, were randomly recruited from a shopping mall in Shanghai, China. Each participant was informed of the general procedures, tasks, and potential risks involved in the experiment. They voluntarily participated and provided written informed consent prior to the study.

2.2 Stimuli

During the eye-tracking experiment, participants were asked to view ten images, each consisting of two waist-up portrait photos displayed side by side—one depicting an individual with autism and the other depicting a neurotypical individual. The paired photos were carefully controlled for gender, hairstyle, clothing, facial shape, and facial expression to ensure visual consistency. Following each image, a dot-probe task was presented, in which a black dot appeared either on the left side or on the right side of a blank screen.

In the subsequent reaction-time experiment, participants completed an Implicit Association Test (IAT) developed using PsychoPy software to assess their implicit attitude toward autistic and neurotypical individuals. The conceptual images were divided into two target categories—"autistic individuals" and "neurotypical individuals"—using the same photographs from the eye-tracking experiment. The attribute words were categorized as positive (e.g., cheerful, reliable, kind, smart, friendly, warm, sincere, resilient, optimistic, positive-minded) or negative (e.g., inarticulate, irritable, disorganized, clumsy, slow-witted, incompetent, withdrawn, dull, sluggish, weird).

2.3 Design and procedure

The study employed a within-subject design. Participants first provided written informed consent. They were then seated in front of a screen connected to a laptop. An eye tracker (Tobii 4C) was placed beneath the screen which was also connected to the laptop. Following a successful five-point calibration procedure, participants viewed images of neurotypical and autistic individuals, as described in Section 2.2. Each image was followed by a dot-probe task. Participants need to identify a black dot presented on a white background. This task lasted approximately five minutes. The eye tracker recorded the entire viewing process. For the images of autistic and neurotypical individuals, areas of interest (AOIs) included the whole face as well as specific facial features such as the eyes, nose, and mouth. Eye-tracking parameters, including total fixation duration (TFD), first fixation duration (FFD), fixation count (FC), and time to first fixation (TFF), were analyzed to quantify participants' visual attention to the stimuli. In addition, TFF during the dot-probe task was recorded across all ten trials.

After completing the eye-tracking session, participants proceeded to the reaction-time experiment, which also used a within-subjects design. Each participant completed both compatible and incompatible tasks while seated at a computer, responding with the 'A' and 'L' keys after reading detailed instructions. The experiment comprised five consecutive steps. To minimize order and practice effects, the

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presentation of compatible trials (positive words paired with autistic individuals and negative words paired with neurotypical individuals, Trials 2–3) and incompatible trials (positive words paired with neurotypical individuals and negative words paired with autistic individuals, Trials 4–5) was randomized across participants. Statistical analyses were based on data from Trials 3 and 5. The remaining trials served to familiarize participants with the procedures and facilitate conceptual and attribute learning (see Table 1 for details).

The experiment concluded once participants completed both the eye-tracking and reaction-time sessions. The total duration of approximately 10-15 minutes per participant. Upon completion, participants received a gift. Following data collection, eye-tracking parameters from the AOIs and participants' accuracy rate and reaction time from the reaction-time task were exported for subsequent statistical analyses.

Table 1: The Results of IAT

Trial	Task	Frequency	Response key	
			A	L
1	Attribute Words Recognition	10	Positive	Negative
2	Conceptual Photos Recognition	10	Autistic Patients	Neurotypical Individual
3	Attributive Words + Conceptual Photos Joint Task	20	Positive + Autistic Patients	Negative + Neurotypical Individual
4	Reverse Conceptual Photos Recognition	10	Neurotypical Individual	Autistic Patients
5	Attributive Words + Reverse Conceptual Photos Joint Task	20	Positive + Neurotypical Individual	Negative + Autistic Patients

2.4 Data analysis

To compare participants' gazing behaviors between photos of autistic and neurotypical individuals, independent-sample t-tests were conducted on total fixation duration (TFD), first fixation duration (FFD), fixation count (FC), and total first fixation (TFF). To further assess participants' attentional bias toward autistic individuals, reaction time from the dot-probe tasks were analyzed using paired-sample t-tests. Response time when the dot appeared on the same side as the autistic individual's photo versus the opposite side was compared.

For the subsequent reaction time experiment, the data was preprocessed before analyses. Trials with incorrect responses (e.g., pressing 'L' when 'A' was required) were excluded. Additionally, reaction times exceeding 3000 ms (> 3SD) were removed, as such delays likely reflected low response confidence. To evaluate participants' implicit attitudes toward autistic and neurotypical individuals, between-group t-tests were conducted to compare reaction time for trials in which autistic photos were paired with positive words or negative words. And D-values were calculated. To examine potential gender differences in implicit attitude, separate within-group t-tests were conducted for female and male participants. D value was calculated for each group.

3. Results

3.1 Independent-sample T-test Analysis of Autistic and Neurotypical Individuals

Table 2. Eye-tracking results of autistic individuals and neurotypical individuals

	TFD(s)		**FFD(s)**		**TFF(s)**		**FC**	
	Neurotypical	Autistic	Neurotypical	Autistic	Neurotypical	Autistic	Neurotypical	Autistic
Face	21.63	24.10	3.52	3.26	9.74	4.42	71.33	76.04

As shown in Table 2, t-test results indicated no significant differences in total fixation duration (TFD), fixation count (FC), or first fixation duration (FFD) between images of individuals with autism and neurotypical individuals ($p > 0.05$). However, analysis of time to first fixation (TFF) revealed that participants fixated on faces of individuals with autism ($M = 4.42, SD = 1.81$) significantly faster than on neurotypical faces ($M = 9.74, SD = 6.31$). The difference is statistically significant ($p < 0.001$).

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3.2 Paired-sample T-test Analysis of Dot-Probe Reaction Time

The results are shown in Table 3, participants exhibited faster TFF for gaze points on the same side as the face of individuals with autism (M=0.73, SD=0.36) compared to gaze points on the opposite side (M=1.02, SD=0.63). Although this difference did not reach statistical significance, the p-value was close to 0.05 (p=0.09).

3.3 D value of Implicit Attitude

In the Implicit Association Test (IAT), the overall D-value for all participants was 0.85, corresponding to an IAT score of 501.32. Male participants exhibited a D-value of 0.93 (IAT score = 547.26), while female participants showed a D-value of 0.86 (IAT score = 473.04).

3.4 T-test Analysis of IAT Reaction Time and Gender Differences in Implicit Attitudes

As shown in Table 3, between-groups t-tests revealed that participants' reaction time in the non-congruent task ($M = 1.53, SD = 0.23$) were significantly shorter than in the congruent task ($M = 2.03, SD = 0.37; p < 0.05$). This pattern was also observed among male participants, whose reaction time in the incompatible task ($M = 1.29, SD = 0.21$) were significantly shorter ($p < 0.05$) than in the compatible task ($M = 1.84, SD = 0.42$). Similarly, female participants demonstrated significantly shorter ($p < 0.05$) reaction time in the non-congruent task ($M = 1.67, SD = 0.21$) compared to the congruent task ($M = 2.15, SD = 0.3$).

Table 3. Results of Implicit Association Tests

		RT (ms)	IAT (ms)	D
Total	Compatible	2028.12	501.32	0.85
	Incompatible	1526.81		
Male	Compatible	1835.05	547.26	0.93
	Incompatible	1287.79		
Female	Compatible	2146.94	473.04	0.86
	Incompatible	1673.90		

4. Discussion

This study aimed to investigate the public's visual attention bias and implicit attitudes toward individuals with autism. The findings revealed a significant attentional bias toward individuals with autism. As the participants showed significantly shorter time to first fixation (TFF) for autistic faces compared with neurotypical ones. In the dot-probe task, participants also demonstrated slightly shorter TFF for probe points appearing on the same side as autistic individuals than for those on the opposite side. This further indicates an early-stage attentional bias toward autism-related stimuli. Data from the Implicit Association Test (IAT) indicated that both female and male participants exhibited significantly negative implicit attitudes toward individuals with autism. Their D-scores approached the threshold range of [-1, 1]. And the reaction time for congruent trials was significantly longer than for incongruent ones which collectively suggests a robust implicit bias.

Overall, the participants showed shorter TFF for autistic individuals and ipsilateral probes in the dot-detection task which indicates a strong attentional bias toward autism-related stimuli. However, there was no significant difference in total fixation duration (TFD), fixation count (FC), or first fixation duration (FFD) between autistic and non-autistic faces. These findings suggest that attentional bias toward autistic individuals occurs primarily during the early, exogenous, and reflexive stages of attention[12]. Prior research suggests that individuals with autism often exhibit facial characteristics that deviate from the population mean—such as differences in facial width-to-height ratio and interpupillary distance—which may enhance exogenous attention capture and subsequently trigger attentional bias[13]. In addition, sociocultural stereotypes may inaccurately associate atypical or non-normative facial features with threat-related cues. These cues could activate the behavioral immune system (BIS) and triggering rapid vigilance responses [14]. This mechanism operates on a "detect first, verify later" principle and results in early attentional capture rather than sustained, late-stage attention[15] .

As shown in Table 2, there was no significant difference in TFD, FC, or FFD between autistic and non-autistic faces. This result suggests that participants did not consciously display biased visual attention toward autistic individuals. One possible explanation is that participants may have regulated

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their gaze behavior according to social norms which discourage overtly differential attention toward minority groups[16]. However, TFF measures are often considered a more sensitive indicator of implicit social attitude[17]. Therefore, the observed TFF differences may reflect automatic attention capture by autistic faces, revealing the existence of implicit biases that participants consciously suppressed during longer viewing durations. This pattern indicates that while overt attentional differences are minimized through social desirability and self-regulation, implicit biases may still operate at the early stages of visual processing.

Data analysis of the Implicit Association Test (IAT) revealed significant negative implicit biases toward individuals with autism. This finding aligns with prior research indicating that, even among those who explicitly hold inclusive attitudes toward autistic individuals, unconscious negative associations often persist. Such biases are likely reinforced by longstanding cultural narratives that portray autistic people as socially inept, deficient, or strange[18][19]. In the compatibility condition of IAT, when participants were required to associate autistic faces with positive words, those having negative stereotypes experienced cognitive conflict, resulting in delayed reaction time. This effect may come from the automatic activation of negative schemas [20]. Furthermore, neuroimaging studies have demonstrated that such cognitive conflict is accompanied by activation in emotional processing regions, particularly the amygdala. This suggests that implicit biases toward autism may originate from subconscious aversive responses triggered by the perception of social atypicality[21]. Findings from fMRI and intracranial EEG research indicate that atypical facial features can activate the amygdala within 70–120 ms after stimulus onset, and that the amygdala modulates eye movements through the superior colliculus–parietal network[22]. This neurobiological evidence corroborates the results of the present eye-tracking experiment, which revealed that the public's visual attention bias toward autistic faces emerged at an early with short TFF.

The IAT results further indicate that male participants exhibited significantly higher D-value than female participants which suggest that men hold stronger negative implicit attitude toward autistic individuals. This gender difference is consistent with prior studies showing that women generally exhibit lower levels of implicit bias toward disability, potentially due to higher emotional empathy and social sensitivity[23]. However, not all studies have found consistent gender effects[24]. Such differences may depend on methodological factors, including variations in measurement procedures, stimulus selection, and sample composition.

Despite the contributions, the present study has several limitations that could be improved future research. First, the participant sample was drawn exclusively from Shanghai—one of China's most economically developed regions. Therefore, findings may not generalize to populations in other cultural or socioeconomic backgrounds. Future studies could include participants from diverse geographic areas to enhance external validity. Second, the stimuli employed in this study consisted of static facial photographs, which may limit ecological validity. Subsequent research could utilize more dynamic and context-rich stimuli, such as short video clips or naturalistic social scenes, to better approximate real-world perception. Third, future investigations could incorporate more physiological measures such as EEG and fMRI to capture the neural correlates of implicit bias. Finally, while this study identified the presence of implicit bias toward autistic individuals, the underlying mechanisms of bias formation remain to be explored. Future work could examine the potential moderating roles of prior contact with autistic individuals, media exposure, and autism-related knowledge in shaping implicit and explicit attitudes.

5. Conclusion

The present study investigated people's implicit attitude and visual attentional bias toward individuals with autism. Using an eye-tracking and dot-probe paradigm, the results revealed an automatic, early-stage attentional bias toward autistic individuals among participants. Analysis of the reaction time from Implicit Association Test (IAT) further demonstrated negative implicit attitude toward individuals with autism. Moreover, males exhibited stronger bias than females. While previous studies have typically employed either the IAT or eye-tracking methods independently, the present research combined both approaches, confirming that early attentional bias and negative implicit attitudes are significantly correlated within the same group of participants. This finding provides behavioral evidence of the two-stage attention–attitude model which suggests that implicit biases may originate from early, automatic attentional processes. These findings highlight the need to reduce implicit biase, promote inclusivity, and prevent the reinforcement of social inequities faced by individuals with autism.

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