# The Effects of Subthreshold Autistic Traits On Time Perception: The Regulation of Interpersonal Information Association

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## Abstract

## Background

People with high subthreshold autistic traits usually show structural impairments like those with autism spectrum disorder, but with less social and cognitive impairments. The effect of autistic traits on time perception and the role of interpersonal information on this effect remains unexplored.

## Methods

This study used a temporal bisection task between 400–1600 ms to compare the time perception of individuals with higher and lower autistic traits, and to explore the influence of interpersonal information on their time perception by establishing associations between interpersonal information and geometric figures. A total of 32 participants with high autistic traits and 31 participants with low autistic traits took part in the study.

## Results

In the absence of identity information, people with high autistic traits tended to judge short durations as longer, and their Weber ratio was higher than those with low autistic traits, suggesting that their overestimation of short duration is due to decreased temporal sensitivity and increased internal clock frequency. With the addition of interpersonal information, individuals with high and low autistic traits had faster responses to self in the identity-figure association, and the subjective bisection point was shorter. However, it took longer for individuals with high autistic traits to build the self-association, and there was no difference in the proportion of long response and Weber ratio between individuals with high and low autistic traits when identity was involved.

## Conclusion

These results suggest that individuals with high autistic traits have a higher central tendency, and this change is related to the decline of perceptual sensitivity. Actively guiding attention to interpersonal information can improve the time perception sensitivity of individuals with high autistic traits.

## Background

Autistic traits refer to a set of behavioral, personality, and cognitive traits associated with autism spectrum disorders (ASDs)(Constantino & Todd, 2003), which are widespread and continuously distributed in both individuals with ASD and the general population(Baron-Cohen et al., 2001; Dawson et al., 2007). People with high levels of autistic traits include both clinical ASD patients and subthreshold high AQ individuals who do not meet clinical diagnostic criteria. The two groups usually show structural

similarities, but different degrees of impairment in social and cognitive functions(Meng et al., 2019). Therefore, the study of high level of autistic traits is of great significance to promote understanding and intervention in individuals with ASD.

The impairment of social function in people with high levels of autistic traits is mainly characterized by social and speech disorders(American Psychiatric Association, 2013), which may be closely related to their impaired ability to represent and process interpersonal information and their reduced sensitivity to social information. "Self" and "other" are two typical interpersonal roles, and people with high levels of autistic traits show some atypical characteristics in their representation and processing of them. Many studies have noted that people with high levels of autistic traits show more extreme self-centeredness(Birch & Bloom, 2004; Frith & de Vignemont, 2005), while others have found that people with high levels of autistic traits have impairments in self-processing. In processing the faces and names of self and close others, individuals with ASD did not show obvious "self-preference effect" as typically developing individuals(Cygan et al., 2014). The absence or reduction of response when infants hear their own name has become the earliest and strongest predictor of ASD diagnosis(Werner et al., 2000). As an extension of self-processing, research on the ownership effect has also made interesting findings. Grisdale et al. (2014) found that typically developing adults were better at remembering objects belonging to themselves, and typically developing children rated objects belonging to themselves as more attractive and valuable than those belonging to others. However, children and adults with ASD did not show a similar "ownership effect." In addition, typically developing individuals showed co-activation in the right prefrontal cortex when seeing the faces of self and others, whereas fMRI studies have revealed that children with ASD do not show these co-activations, which may be due to their lack of understanding of the commonality between self and others and the neural mechanism of impairments in interpersonal consciousness(Uddin et al., 2008). These results suggest that atypical self-processing and other-processing may occur simultaneously in high AQ individuals. A better understanding of self often means a better representation of others' minds and better processing of interpersonal information(Conway et al., 2019; Shah et al., 2017). It should be noted that the level of autistic traits may play an important and subtle role in the processing of interpersonal information. Gillespie-Smith et al. (2018) suggested that individuals with severe ASD tended to show an "absent self," while individuals with mild ASD were less likely to pay attention to others and showed a higher self-bias tendency.

Researchers are more likely to overlook changes in cognitive function compared to impairment of social function in individuals with high AQ. Time processing is the basis of many complex cognitive functions, such as attention, memory, emotion, and language, and it is crucial to an individual's cognitive development(Szelag et al., 2004). However, previous studies have reported controversial results. Some scholars have found that high levels of autistic traits may lead to the enhancement of time perception(Mottron et al., 2006). The higher the level of autistic traits, the more likely participants were to form a more stable and accurate representation of pitch and time to auditory stimuli(Stewart et al., 2018). It was also found that individuals with ASD showed better temporal resolution in visual modality(Falter et al., 2012). Studies have reported that the temporal estimation of individuals with ASD is not enhanced in the sub-second range, at least is undamaged (Edey et al., 2019). However, self-reports of individuals with

ASD, as well as reports from relatives or physicians who have frequent contact with them, suggest that they have impaired subjective time perception in their daily lives(Casassus et al., 2019). Some researchers have even suggested that the impairment of time processing is one of the key characteristics of individuals with ASD(Allman et al., 2011). Jurek et al. (2019) reviewed timing-related studies, ranging from circadian rhythms and minutes to seconds and milliseconds, finding that time processing in individuals with ASD was defective at almost all levels, showing greater variability, higher discrimination thresholds, and lower accuracy. It is suggested that early intervention in children's time perception may help improve the patient's developmental trajectory. However, previous studies on different time ranges showed that the mechanisms of autistic traits were not the same for short- and long-time processing. Children with high functional ASD showed relatively large errors in time replication tasks of both 500 ms and 45 s; however, the errors for short time were related to basic sensory processing and timing pulse release, and the errors for long time may be related to higher cognitive processing, such as attention and memory(Maister & Plaisted-Grant, 2011).

In addition, an interesting phenomenon in time processing is that individuals often show a "central tendency" that approaches the average, that is, a tendency to underestimate a relatively long period of time and overestimate a relatively short one. This "central tendency" is a flexible cognitive strategy to improve accuracy at the expense of sensitivity when an individual's perceptual ability is insufficient to make a clear judgment. However, with age, the typical developing children's perceptual ability increases, the "central tendency" decreases, and the time resolution increases accordingly. In contrast, children with clinically high AQ have a higher "central tendency" than typically developing children of the same age; they show more conservative responses to time perception tasks and report fewer differences between time intervals(Karaminis et al., 2016).

As a breakthrough in the understanding of cognitive processing mechanisms in clinical ASDs, Nijhof and Bird (2019) found that the level of autistic traits affects not only the processing of social information, but also the broader, varied domains of cognitive processing. However, how the ability to represent and process interpersonal information affects other cognitive processes related to autistic traits remains to be explored. The influence of autistic traits on time perception is also concentrated in individuals with clinically high AQ. In this study, we focused on individuals with subthreshold high AQ who have mild social and cognitive impairments and better task completion. Starting from basic time perception, we further explored the impact of autistic traits on cognitive function in more detail. We wanted to investigate the variability, accuracy, sensitivity, and concentration tendency associated with time perception with subliminal autistic traits through a temporal bisection task in the 400–1600 ms range. The representation and processing of interpersonal information is an important basis for influencing social interaction and an important factor in the regulation of individual cognitive processing with autistic traits. As interpersonal information, such as self or other identities, has specific biological and social significance to individuals, it can also directly affect subjective time perception as a prominent stimulus. For example, individuals usually overestimate the duration of their own names. When personality trait words are used as stimuli, the duration of self-reference negative trait words is often judged to be longer than that of friend-reference words(Li et al., 2019). In this study, we specifically introduced the geometric

shapes that match in physical characteristics and established their associations with self and others as visual stimuli. After matching the physical characteristics carried by interpersonal information, we explored how the level of autistic traits is modulated by interpersonal information, which further affects the basic perception of time, so as to provide a relevant theoretical basis for cognitive intervention in ASD.

# Experiment 1

## Participants

A total of 280 the revised Chinese version of Autism Spectrum Quotient (AQ) questionnaires were distributed among undergraduates and postgraduates using convenience sampling, and 249 valid questionnaires were obtained. The groups with high level of autistic traits and low level of autistic trait (hereinafter referred to as "high AQ group" and "low AQ group") was based on grouping criteria of previous studies(Burnett & Jellema, 2013; English et al., 2017; Whyte & Scherf, 2018). Based on total scores, the top and bottom 27% of the individuals were selected, combined with the AQ score range, and according to the willingness of the participants, 63 participants were finally recruited to participate in the study. There were 32 participants (9 males and 23 females) in the high AQ group with an average age of 20.65 ± 1.51 years and average AQ scores ranging from 125 to 161, with an average score of 130.03 ± 5.94. In the low AQ group, there were 31 participants (14 males and 17 females) with an average age of 19.39 ± 1.66 years and an average AQ score of 102.87 ±4.48, in the range of 89-110. An independent samples t-test showed that the AQ scores of the two groups were significantly different. All participants had normal visual acuity or corrected normal visual acuity, were right-handed, and volunteered to participate in the experiment. After completion of the experiment, the participants were able to obtain the corresponding compensation. All participants signed an informed consent form before the experiment, and the study met ethical standards.

## Methods

### Measures

The Autistic Spectrum Quotient (AQ) is a widely used tool to measure autistic traits. It was developed by Baron-Cohen et al. (2001) and is mainly used to measure the level of autistic traits in non-clinical populations. The revised Chinese version, by Zhang et al. (2016), was used in this study. AQ includes five dimensions: social skills, attention to conversion, attention to detail, communication, and imagination, with a total of 50 questions. Each question has four options, from "completely agree" to "completely disagree," using a four-point, Likert scoring method. The higher the score, the higher the level of autistic traits. The internal consistency coefficient of the revised Chinese version is 0.81, the retest reliability is 0.89, and the internal consistency coefficient of each subscale is between 0.62-0.76. The internal consistency coefficient of the AQ in this study was 0.71.

### Procedures

In Experiment 1, a temporal bisection task was used(Droit-Volet et al., 2004), which was divided into three stages: training, training test, and formal experiment stage. During the training stage, gray diamonds (with a long diagonal of 5 cm and a short diagonal of 3 cm) were alternately displayed in the center of the screen at 400 ms and 1600 ms, five times each. The participants were informed that 400 ms was the standard short duration and 1600 ms was the standard long duration. At this stage, participants needed to feel subjectively and try to remember the standard long and short duration, but no response was required. In the training test stage, gray diamonds with standard long or short durations were randomly presented in the center of the screen, and the participants were asked to judge "long" or "short" according to the duration length, pressing the "F" or "J" keys, respectively, to respond. Correct and incorrect feedback was provided in this stage. After 10 training trials, the participant could only enter the next stage if all the choices were correct. In the formal experimental stage, the visual stimulus appeared at the center of the screen, randomly, in one of the seven intervals of 400, 600, 800, 1000, 1200, 1400, and 1600 ms, and the participants were asked to judge whether the time interval was closer to the standard long duration or short duration. There were 196 trials in the formal experiment, each duration was randomly presented 28 times, and the interval between trials was random within 1-3 s. The procedure for Experiment 1 is shown in Figure 1.

## Data statistics

The proportion of long response, subjective bisection point, and Weber ratio were calculated according to the judgments made by the participants. According to the study by Droit-Volet et al. (2004), the proportion of long response refers to the proportion of the frequency whose duration is judged to be close to a long duration to the total frequency under a certain condition. The subjective bisection point was the duration corresponding to the proportion of long response of 0.5. The Weber ratio is defined as half of the difference between the duration corresponding to the proportions of long response of 75% and 25%, divided by the subjective bisection point. In this study, the sigmoid function was used to fit the proportion of long response, and the subjective bisection point and Weber ratio of each participant were calculated using the fitting function.

## Results

A two-factor of 2 (autistic traits: high AQ group and low AQ group) × 7 (duration: 400-1600 ms) repeated-measures ANOVA was performed for the proportion of long response. As shown in Figure 2a, there was no significant difference in autistic traits. The main effect of duration was significant, and the post-hoc test showed that the difference in the proportion of long response between 1400 and 1600 ms was not significant, the difference in the proportion of long response ratio between the other two durations was significant, and the proportion of long response of the long duration was significantly greater than that for the short duration. The interaction between duration and autistic traits was significant. Further simple effect analysis showed that the proportion of long response of the high AQ group was higher than that of the low AQ group at 400, 600, and 800 ms, but there was no significant difference in the proportion of long response between the two groups at the four durations of 1000, 1200, 1400, and 1600 ms.

The proportion of long response was fitted with an S-shaped curve to calculate the subjective bisection point and Weber ratio. An independent samples t-test was conducted to calculate the subjective bisection and Weber ratio of the two groups. The statistical results showed that there was no significant difference between the high and low AQ groups in the subjective bisection point. The Weber ratio of the high AQ group was significantly higher than that of the low AQ group.

As shown in Figure 2b, there were no significant differences in the levels of autistic traits. The main effect of duration was significant, where the reaction time at 800 ms was significantly longer than that at other durations, the reaction time at 1600 ms was significantly shorter than that at other durations, and the reaction time at 400ms was significantly shorter than those at 600, 800, and 1000 ms, and significantly longer than those at 1400 and 1600 ms. The reaction times at 600 and 1000 ms were significantly greater than those at 1200, 1400, and 1600 ms, and the reaction time at 1200ms was significantly longer than those at 1400 and 1600 ms. The interaction between autistic traits and duration was not significant.

## Discussion

A classical temporal bisection task paradigm was used to explore the difference in time perception between high and low AQ groups in Experiment 1. After learning the standard short duration of 400 ms and the standard long duration of 1600 ms, participants judged the length of seven durations in the range of 400-1600 ms. We found that the proportion of long response in the high and low AQ groups increased with increasing duration, and participants responded faster to the long and short standard durations, especially for the standard long duration. However, we found no differences between groups and interactions on reaction time, suggesting that both groups can make a relatively accurate estimation within the range of duration. The perception of a short duration, ranging from ms to s, is the basis of longer duration perception and reflects purer perceptual processing. Changes in long duration perception may be an accumulation, amplification, and adjustment of short duration perception, and involve the participation of higher cognitive processes such as attention and working memory (Maister & Plaisted-Grant, 2011). Therefore, greater focus should be shifted to the influence of attention and working memory on the exploration of time perception related to autistic traits.

Although there was no difference in the overall trend of time perception between the two groups, a careful analysis of the proportion of long response showed that there was an interaction between duration and autistic traits. Compared with the low AQ group, the proportion of long responses was higher for the group with high AQ at 400, 600, and 800 ms, but there was no significant difference in the longer durations. This is consistent with the central tendency proposed by researchers (Karaminis et al., 2016), in which people tend to overestimate relatively short durations, showing the central trend in the short duration but not in the relatively long duration. In addition, the increase in the Weber ratio in the high AQ group suggests that its temporal sensitivity and temporal accuracy are reduced, which may be related to the change in the internal clock release rate and the adjustment of attention during timing.

In conclusion, we found that individuals with high AQ tended to have similar perceptual abilities to those with low AQ in Experiment 1. The difference was that individuals with high AQ tended to overestimate the

shorter duration, and the Weber ratio suggested that the temporal sensitivity of high AQ individuals was relatively poor, which might be one of the reasons for their overestimation of short duration.

# Experiment 2

## Participants

The participants in Experiment 2 were the same as in Experiment 1.

## Methods

A combination of a identity-association task and a temporal bisection task was used in Experiment 2. The participants were required to complete a task of identity association learning before completing the temporal bisection task. Referring to the self-figure association paradigm(Sui et al., 2012), this task was divided into three stages. In the first stage, the participant was asked to imagine the square, triangle, and circle as the self, a friend of the same sex, and a stranger, respectively. The color and angle of the outer circle of the figures were the same within the three geometric figures. The second stage was an identity association exercise with a total of 18 trials. A geometric figure was randomly presented in the center of the screen, and three identity labels "me," "friend," and "stranger" were displayed below the figure. The participants selected the identity corresponding to the current geometric figure using "B," "N," and "M" on the keyboard. Correct or incorrect feedback was provided at this stage. The third stage was a formal experiment of identity association, which proceeded almost similarly as second stage, except that no feedback was provided. There were 216 trials in the formal identity association stage, and each figure was presented 72 times randomly. The association between figures and identity information was balanced among participants. After the identity association learning, the participants completed the temporal bisection task immediately. This part was basically the same as in Experiment 1, except that the gray diamond was replaced with three types of geometric figures, representing the self, a friend of the same gender, and a stranger. There were 588 trials in the temporal bisection task, and each of the seven durations appeared 28 times. The interval of each trial was random within 1-3 s.

## Results

The data of four participants were excluded because their response time exceeded three times the standard deviation at response time, and the remaining 59 participants (31 in the high AQ group and 28 in the low AQ group) were included in the statistical analysis of accuracy, response time, and proportion of long response. A 2 (autistic traits: high AQ and low AQ) × 3 (identity: self, friend, and stranger) repeated-measures ANOVA was used for the response time in the identity associative learning stage. The results showed that there was a significant difference between the two groups, and the response time of the high AQ group was significantly longer than that of the low AQ group. The main effect of identity was significant, and the post-hoc test showed that the response time to self was significantly shorter than that to the friend or stranger, as shown in Figure 3. The accuracy of the two groups was more than 96.30%, and no significant difference between the two groups was found.

Regarding the temporal bisection task involving identity information, the pattern of long response proportion of one participant in each of the two groups did not conform to the characteristics of the S-curve, and the fitting parameters exceeded three times the standard deviation; therefore, the subjective bisection points and Weber ratio obtained from the fitting data were removed, and the data of the remaining 57 participants (30 in the high AQ group and 27 in the low AQ group) were entered into the statistical analysis of the proportion of long response, subjective bisection point, and Weber ratio. Combined with the condition of no identity information, the proportion of long response was performed using a three-factor repeated-measures ANOVA of 2 (autistic traits) × 7 (duration) × 4 (identity), the results of which are shown in Figure 4a. There was no significant difference between the high and low AQ groups. The main effect of identity was significant, and the post-hoc test showed that the proportion of long response for no identity was significantly lower than that for self, friend, and stranger. The main effect of duration was significant, and a post-hoc test showed that there was no significant difference in the proportion of long response between 1400 ms and 1600 ms, whereas the proportion of long response of each two durations were found to be significantly different between all the other long and the short durations.

A three-factor of 2 (autistic traits) × 7 (duration) × 4 (identity) repeated-measures ANOVA was performed on the response time of the temporal bisection task. As shown in Figure 4b, the results showed that there was no significant difference between the high and low AQ groups. The main effect of identity was significant, and a post-hoc test showed that the response time of no identity was significantly longer than that of the other three identities. The main effect of duration was significant, and a further post-hoc test showed there was no significant difference between the durations of 400 and 1000 ms, whereas significant differences were found between other pairwise durations. The interaction between identity and duration was significant, and there was no significant difference among all the identities at short durations of 400 and 600 ms. However, for long durations, including 800, 1000, 1200, 1400, and 1600 ms, the response time of no identity was significantly longer than that of the friend, self, and stranger. The remaining two or three interactions were not statistically significant.

A two-factor of 2 (autistic traits) × 4 (identity) repeated-measures ANOVA was performed for the subjective bisection point and Weber ratios, as shown in Figure 5. The results of the Weber ratio showed that the main effect of identity information was significant, and the Weber ratio of stranger was significantly lower than that of no identity and friend. At the level of autistic traits, the difference in the Weber ratio between the two groups was not significant. The interaction between autistic traits and identity was significant, and further analysis showed that for the no identity condition, the Weber ratio of the high AQ group was significantly higher than that of the low AQ group, but there was no significant group difference in the Weber ratio for any of the other identities. In addition, there was no significant difference among all the identities in the low AQ group, but in the high AQ group, the Weber ratio of no identity was significantly higher than those of self and stranger. In addition, the Weber ratio of friend was significantly higher than that of stranger, and the Weber ratio of stranger was significantly lower than that of no identity and friend.

The results of the subjective bisection points showed that the main effect of identity information was significant, and the subjective bisection of no identity was significantly higher than that of friend, self, and stranger. There was no significant group difference between the two groups and no interaction between autism traits and identity.

## Discussion

In Experiment 2, we combined an identity-association learning task and a temporal bisection task to investigate time perception-related autistic traits under different identities. In the identity-association learning stage, both groups showed higher accuracy and responded faster to self than friend and stranger, showing an obvious self-advantage effect. However, the response time of the high AQ group was significantly longer than that of the low AQ group during identity-association learning, suggesting that more effort should be devoted to the processing of social identity information for high AQ individuals and to establish the association between geometric figures and identity information.

Once the association between identity information and geometric figures was established, this study found that the involvement of social identity promotes the processing speed of duration, especially in the processing of longer durations, suggesting that changes in time processing are accumulated and amplified for longer durations. From the analysis of the variability of time perception, the results indicate that the proportion of long responses for geometric figures is lower than that of self, friend, and stranger, and the subjective bisection point for the geometric figure is higher than that of all identities. Based on a temporal range, from 400 to 1600 ms, 1000 ms should be the objective bisection point. However, with the involvement of the three social identities, the subjective bisection points were all less than 873 ms, suggesting that individuals tended to overestimate and show greater variability when processing durations carrying social identities.

The analysis of the Weber ratio can further reveal sensitivity differences in individual time perception. In addition to the stranger conditions characterized by a lower Weber ratio and higher sensitivity to time perception, we found an interesting interaction: the Weber ratio of the low AQ group showed little difference under the condition of various social identities, whereas high AQ seemed to be more vulnerable to duration, regardless of whether it involves social identity. The high AQ group showed a higher Weber ratio and time processing precision in the absence of social identities. After the involvement of social identity, the high AQ group increased their temporal sensitivity, and the difference between the low AQ and high AQ groups disappeared. The forced social identity association from the task demand increased the time sensitivity of the high AQ group, which may be due to the higher arousal of social identities compared to geometric figures(Li et al., 2019), regulating the speed of pulse during temporal processing. Response time data suggest that the response time of no identity was slower than that of social identities, which also confirms the results of the Weber ratio.

# Total Discussion

Temporal processing is the basis of almost all human cognitive processes. In previous studies, the clinical population with high level of autistic traits is reported to have defects in temporal processing, but the performance of high AQ individuals with different temporal ranges is controversial(Isaksson et al., 2018; Jurek et al., 2019). Given the fact that long duration processing may be involved in higher cognitive processing (Maister & Plaisted-Grant, 2011), we detected the characteristics of time perception in non-clinical individuals with high autism traits within a temporal range of 400 to 1600 ms, in terms of perceptual accuracy, direction of deviation, and temporal sensitivity, through the proportion of long response, subjective bisection point, and weber ratio, respectively. The results show that the overall trend and response pattern of high and low AQ individuals are basically similar, within the range of hundreds of milliseconds to seconds, and both groups had an increased proportion of judgment for "long" along with an increase of duration length, indicating that they have a rather accurate temporal perception. A more detailed analysis indicated that individuals with high AQ tended to overestimate short durations, and the trend of overestimation disappeared at the longer end of the temporal range, but did not show underestimation of long durations. The present results are relatively consistent with the conclusion of the pervious study, namely high AQ individuals showed a certain "central tendency" with a more conservative response pattern in the time perception task(Karaminis et al., 2016). Because the longest duration (1600 ms) was relatively short in the present study, we only observed a trend from overestimation to gradually decreased overestimation for relatively short and relatively long durations. It may be necessary to add longer durations to detect changes in time perception at the other end of the duration range. In addition, individuals with high AQ have a higher Weber ratio than those with low AQ, which suggests that they have decreased temporal sensitivity, tend to overestimate short durations, and find it difficult to adjust to short durations. Central tendency is one of the most common performances in individuals with high AQ, indicating increased variability of time perception, but the temporal dimension is usually combined with various types of information, and individuals with high AQ often lack sufficient sensitivity to social information (Howard et al., 2019). If we actively direct attention to social information by adding social information and giving task instructions, it is possible to adjust or improve the performance of perceptual processing (Jones & Klin, 2013; Wang et al., 2020).

Due to the sensitive and high-arousal nature of social information, identities may have a definite influence on basic cognitive processing, including sensory, perception, attention, and memory. The present study combined the identity association task and classical temporal bisection task, where participants needed to complete identity association learning before the time perception task. Individuals with high AQ expended more cognitive effort to complete identity-figure association, and it is important to note that even though they took longer in association learning, their response time under the self-condition was shorter than that of the friend and stranger conditions. These results suggest that individuals with high AQ are not sensitive enough to relationships, specifically social relationships, but compared with other identities, they prioritize self-processing.

The effect of identity association learning has several points on the time perception. First, identity information improves individual arousal, changes the speed of pulse in temporal processing, reduces the subjective bisection point, and increases the proportion of long response. In this study, we found that

after the learning of identity-figure association, the subjective bisection points of self, friend, and stranger were all lower than those of no identity. In the long duration of 1600 ms, the proportion of long response showed a significant difference between different identities, but this difference was not found in the short durations, suggesting that after learning the identity information, participants took a long time to process identities and influence time perception. Second, as found in previous studies on individuals with ASD (Jones & Klin, 2013; Wang et al., 2020), when participants' attention is directed to social information based on task requirements, the cognitive processing of high AQ individuals can be improved, which also suggests that reasonable and effective interventions can work to a certain extent. Compared to the no identity condition, this study found that the Weber ratio of various identities decreased for individuals with high autism traits after identity association learning, suggesting that temporal sensitivity increased as well as the accuracy of temporal perception by the binding of social information based on task requirements. Social information can be proved to influence basic time perception, providing an important means that can be used for future interventions.

The participants selected in this study were distributed at the high and low ends of autistic traits; thus, the correlation between autistic traits and the sensitivity or deviation of time perception was not explored in detail. The temporal range of this study was concentrated in the short duration from hundreds of milliseconds to one second, and it can be speculated that a longer duration is more likely to accumulate and magnify deviations in time perception. In addition, identity association learning was set before the time perception task, and the participants showed relatively high accuracy and variation in time perception from identities. However, if more direct social information was added to the time perception task, and the differences between various social information were further balanced, the influence of social identities on time perception may be more direct.

## Conclusion

In this study, we used a temporal bisection task to explore the effect of autistic traits on time perception in the range of 400–1600 ms and investigated the effect of the involvement of different identities through social identity associative learning. The results showed that individuals with high AQ were relatively accurate in their time perception of this temporal range, but they tended to overestimate the short duration of this range, and their temporal sensitivity decreased. It took longer for individuals with high autistic traits to establish social identity association. Task-directed identity information reduced subjective bisection points and increased the proportion of long response, suggesting that their temporal sensitivity and accuracy were improved after the introduction of social identities.

## List Of Abbreviations

ASD: Autism Spectrum Disorder;

AQ: Autism Spectrum Quotient;

high AQ: high levels of autistic traits;

low AQ: low level of autistic traits

# Declarations

## Ethics approval and consent to participate

All the methods were performed in accordance with Declaration of Helsinki.

The study was approved by the ethics committee of Anhui Normal University, Approval Number: 2019014. All participants signed informed consent forms.

## Consent for publication

Not Applicable.

## Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

## Competing interests

We have no financial or personal conflicts of interest to declare.

## Authors' contributions

XB and YL were involved in designing the research, writing the research protocol, and supervising subjects' recruitment. YL and LS conducted data collection. LS and XB completed the data processing and analysis. XB and LS drafted the manuscript, XB revised the manuscript. All authors read and approved the final manuscript.

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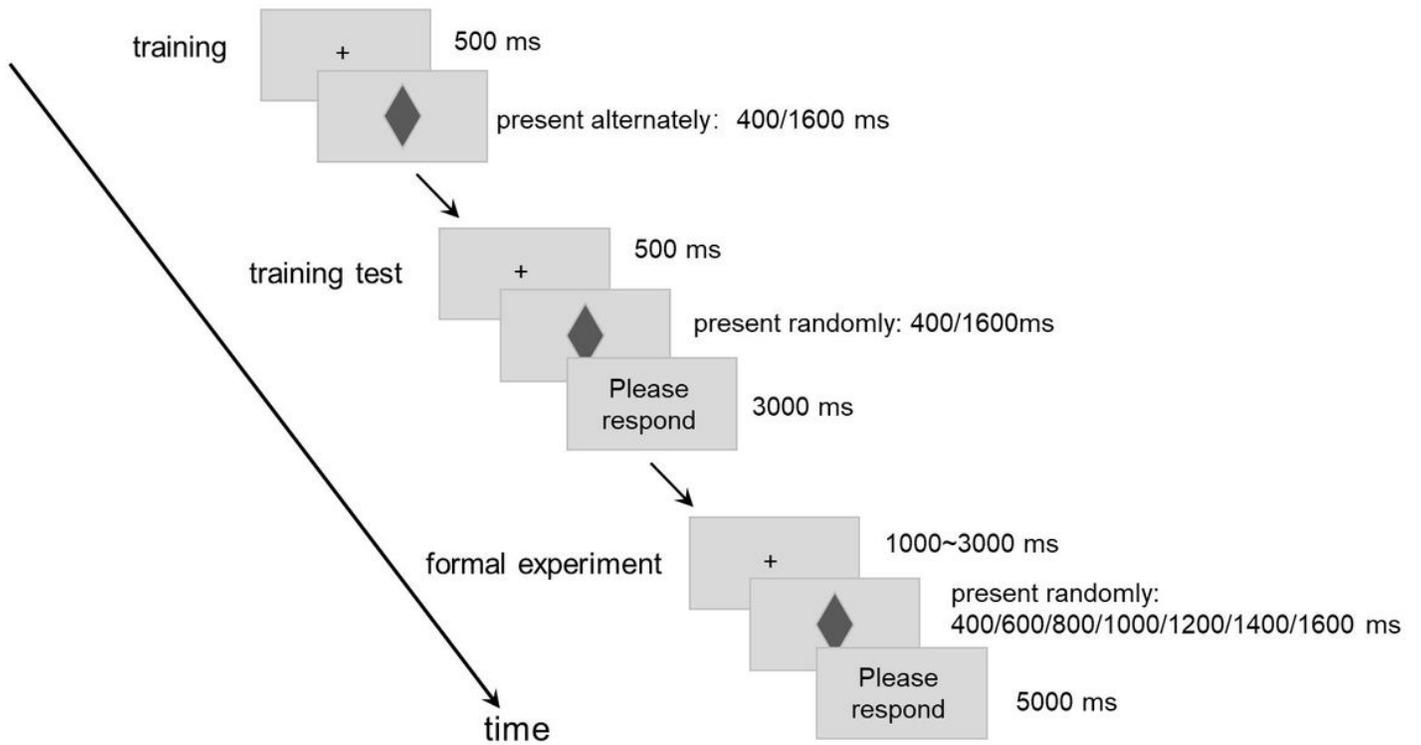
# Figures

## Figure 1

The procedure of Experiment 1
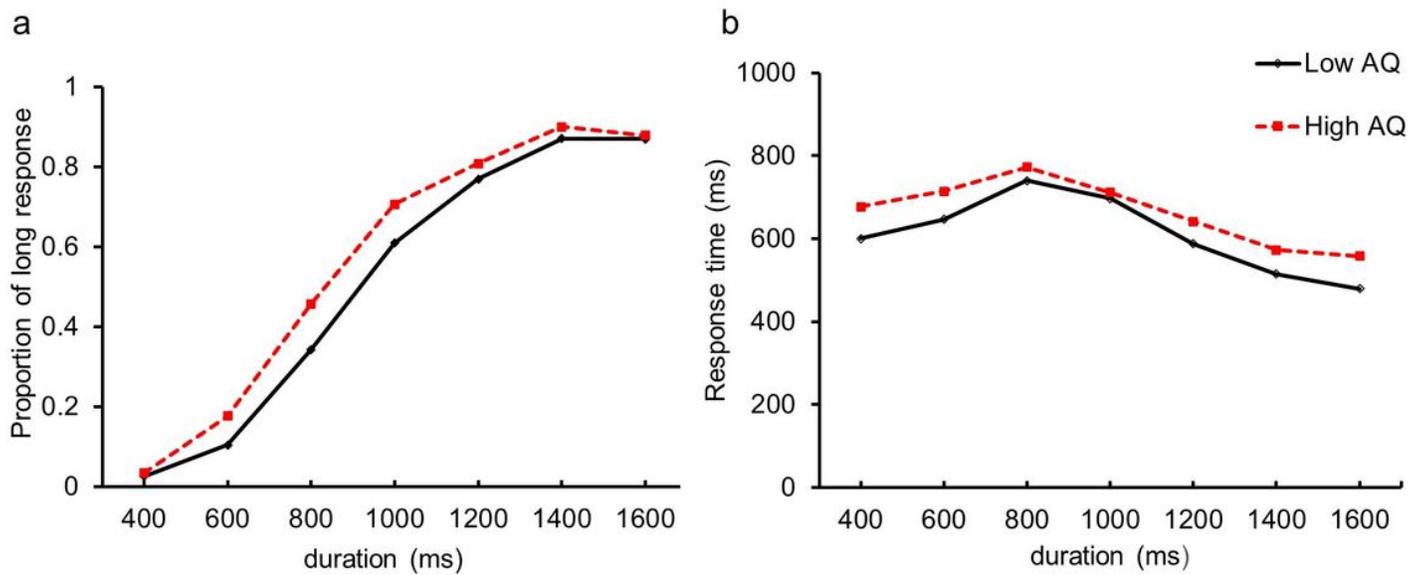


## Figure 2

The proportion of long response (a) and response time (b) in temporal bisection task
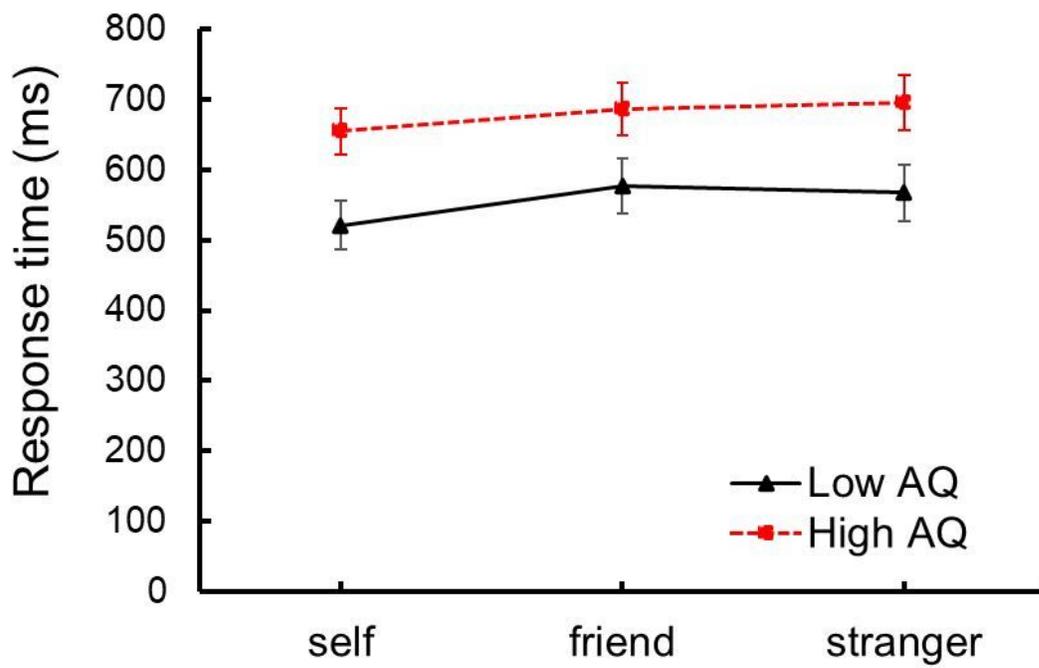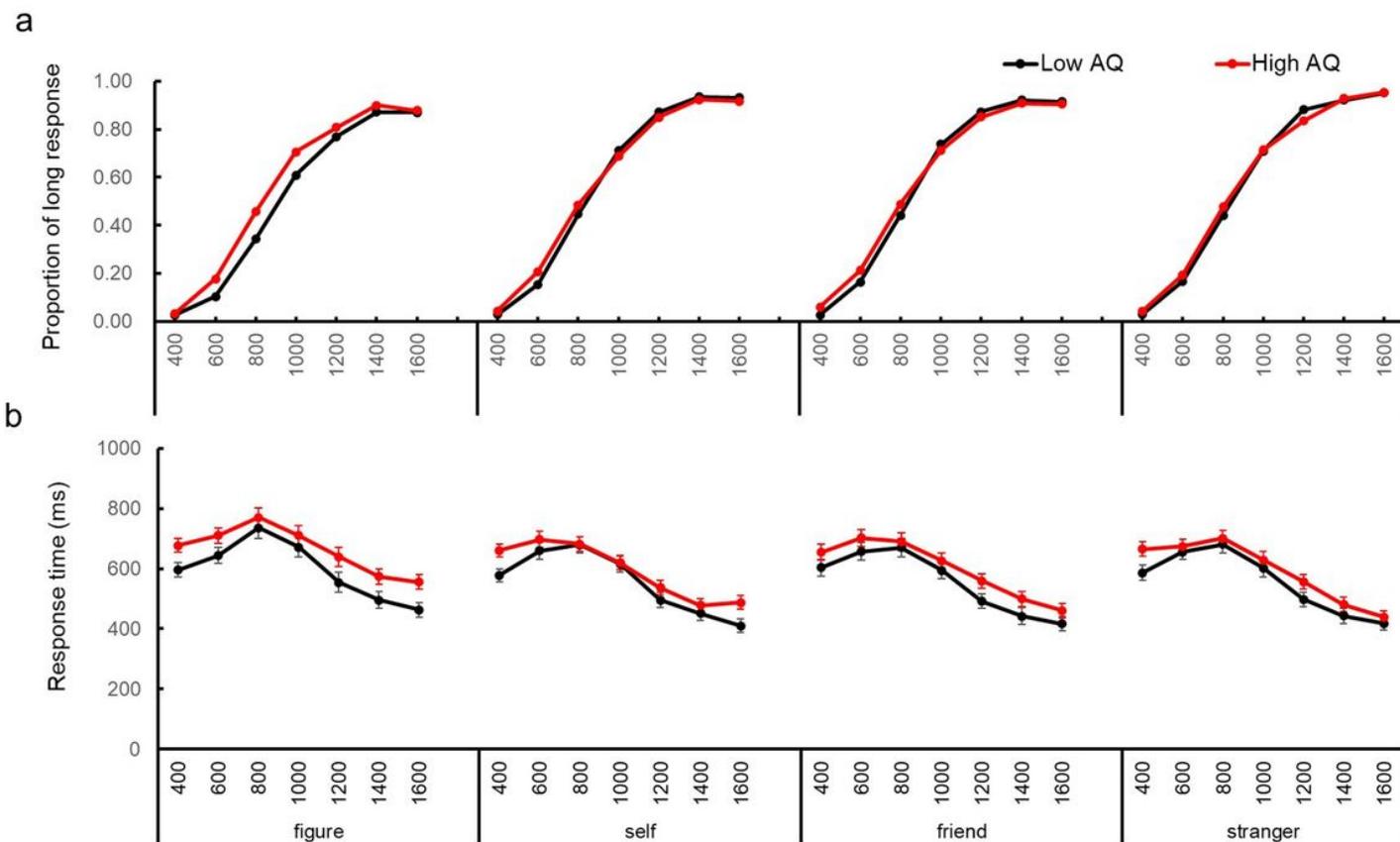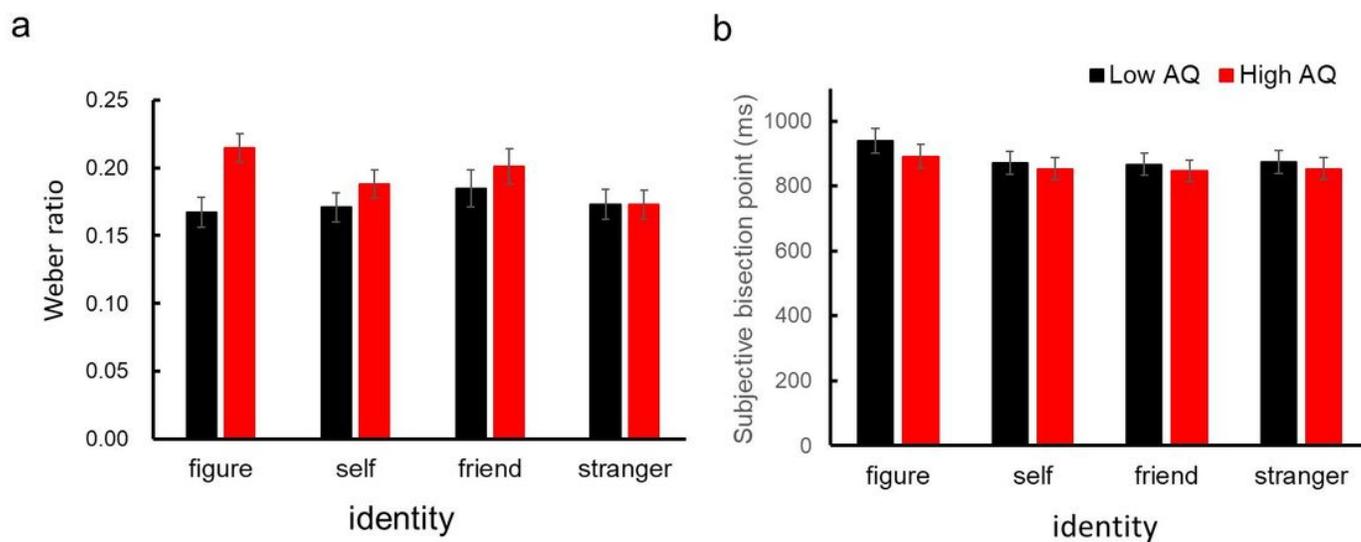
**Figure 3**

The response time of identity-figure association learning in the high and low AQ groups

**Figure 4**

The proportion of long response (a) and response time (b) in a combination of temporal bisection task and identity-association task



**Figure 5**

The Weber ratio (a) and subjective bisection point (b) in a combination of temporal bisection task and identity-association task