

Visual Exploration Efficiency Moderates the Association Between Autistic Traits and Social Cognition

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Abstract

Social cognitive impairments are among the strongest predictors of functional difficulties in autism, yet the mechanisms linking autistic traits to social cognitive deficits remain unclear. One potential mechanism involves visual exploration – the eye movements through which social information is sampled from the environment – which operates upstream of social perception. In this study we examined whether visual exploration efficiency moderates the relationship between autistic traits and social cognition across a hierarchy spanning gaze detection, emotion recognition, and theory of mind. A sample of 162 adolescents and young adults (ages 14-30) with varying levels of autistic traits completed a gaze detection task with concurrent eye tracking, an emotion recognition task, and a video-based social inference task; basic visual processing was also assessed to rule out low-level visual confounds. A moderated serial mediation model showed that higher autistic traits were associated with reduced gaze perceptual precision, which was in turn associated with poorer emotion recognition, which was in turn associated with lower theory of mind accuracy. Visual exploration moderated the first link in this hierarchy: the association between autistic traits and reduced precision was present at low and average but not high levels of visual exploration, and this buffering effect propagated through the full pathway to theory of mind. The model also revealed a direct pathway from autistic traits to emotion recognition that was independent of gaze perception. These findings suggest that visual exploration is a source of heterogeneity in social cognitive outcomes among individuals with elevated autistic traits and a potential target for intervention, while also indicating that addressing social cognitive difficulties in autism will require strategies beyond perceptual training alone.

Keywords: Autistic Traits, Social Cognition, Visual Exploration, Eye-Tracking

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Introduction

Individuals with autism spectrum disorder (ASD) consistently demonstrate difficulties in social cognition - the ability to perceive, interpret, and respond appropriately to social information (Baron-Cohen, Wheelwright, Hill, et al., 2001; Happé & Frith, 2014; Losh & Capps, 2006). A person might misread a colleague's neutral expression as disapproving, fail to notice that a conversation partner has lost interest, or miss the affective nuance in how something is said rather than what is said. In daily life, such difficulties manifest in struggles to infer others' intentions from subtle social cues, or interpret the meaning conveyed through tone of voice. These social cognitive impairments are among the strongest predictors of difficulties in everyday social functioning for people on the autism spectrum (Morrison et al., 2020). Such difficulties manifest in everyday life as challenges with maintaining employment, sustaining friendships, and navigating daily social interactions (Bishop-Fitzpatrick et al., 2017).

Notably, social cognitive difficulties are not limited to individuals who meet full diagnostic criteria for ASD. Research has documented similar patterns among individuals with elevated autistic traits who fall below clinical thresholds (Chen & Yoon, 2011; Freeth et al., 2013; Hessels et al., 2018). These findings support a dimensional conceptualization of autism, wherein social-communicative differences exist along a continuum across the broader population rather than as a categorical distinction (Mandy et al., 2018).

Current treatments have yet to fully address these social challenges (Bishop-Fitzpatrick et al., 2014), making it essential to understand the mechanisms underlying these impairments. Tracing these difficulties back to more fundamental component processes may help clarify the mechanisms underlying social dysfunction across the autism spectrum and illuminate potential intervention targets (Green et al., 2015; Leekam, 2016).

Indeed, social cognition can be conceptualized as a hierarchical system, where basic perceptual processes provide the foundational inputs for increasingly complex social judgments (Adolphs, 2009). At the most fundamental level, a core social-perceptual skill is perceiving gaze direction, because the eyes convey information about others' attention, intentions, and mental states, making accurate gaze perception essential for successful social interaction (Itier & Batty, 2009; Kleinke, 1986).

Gaze detection is then fundamental to emotion recognition because gaze direction itself carries rich emotional information (Adams & Kleck, 2005; Liang et al., 2021). For example, when experiencing shame or embarrassment, individuals tend to avert their gaze downward; suspicion or alertness is often accompanied by lateral gaze shifts; and uncertainty or contemplation typically manifests as upward gaze (Glenberg et al., 1998; Servais et al., 2022, 2023). Thus, accurately perceiving where another person is looking provides critical cues for inferring their emotional state. Building upon this foundation, the ability to decode emotional expressions from the eye region requires integrating subtle perceptual cues - including gaze direction - with stored knowledge about emotional states (Baron-Cohen, Wheelwright, Hill, et al., 2001). Sensitivity to subtle changes in gaze direction therefore supports not only the detection of social attention but also the recognition of emotions from facial expressions. Lack of sensitivity to subtle changes in gaze direction may thus cascade into difficulties with emotion recognition.

Emotion recognition impairments have been robustly associated with autistic traits in both clinical and subclinical populations (Baron-Cohen, Wheelwright, Hill, et al., 2001; Penuelas-Calvo et al., 2019; Warrier et al., 2018). Together, gaze detection and emotion recognition can be conceptualized as hierarchically organized building blocks of social cognition - component processes that feed forward into more complex social judgments, such as those required for theory of mind in naturalistic contexts, which demand the synthesis of gaze, facial expressions, and contextual information to infer complex mental states and social meanings (Stephenson et al., 2021). Disruptions at lower levels of this hierarchy may cascade upward (Happé & Frith, 2006), compromising performance on more complex social cognitive tasks even when higher-order reasoning abilities remain intact (Chevallier et al., 2012).

The Role of Visual Exploration

The social-cognitive processes described above - from gaze detection to emotion recognition to theory of mind - all depend on visual input. Indeed, vision is the dominant sensory modality for collecting social information in humans (Birmingham et al., 2009b), but critically, this visual information must be actively sampled through eye movements before it can be processed (Frischen et al., 2007; Henderson, 2003). Visual attention and exploration therefore operates *upstream* of perceptual encoding: how individuals move their eyes across social scenes determines both the quality and quantity of information available for subsequent social-cognitive

processing. Consequently, the efficiency with which individuals sample visual information from social stimuli and social scenes directly shapes their ability to perceive and interpret social signals (Birmingham et al., 2009a; Risko et al., 2016).

Eye-tracking research has consistently documented atypical visual attention patterns in autism, including reduced attention to the eye region, decreased spontaneous gaze to faces, and altered scanning patterns, particularly during free viewing of social scenes in the laboratory (Jones et al., 2008; Klin et al., 2002; Pelphrey et al., 2002), while behavior under explicit task demands has proved to be more normative (DeStefani et al., 2026). Meta-analytic evidence across laboratory eye-tracking paradigms confirms that individuals with autism spend significantly less time attending to social stimuli compared to neurotypical controls, particularly when stimuli depict multiple people (Chita-Tegmark, 2016).

Visual attention unfolds through the coordinated interplay of saccades and fixations during visual exploration of a scene: saccades are rapid eye movements that redirect gaze across the scene, while fixations are the intervening periods of relative stability during which visual information is extracted (Henderson, 2003). The efficiency of this sampling process – reflected in the amplitude and frequency of saccades, and in the number and duration of fixations – determines the amount of information available for subsequent processing, making it a critical determinant of social-perceptual performance.

Individuals with autism and elevated autistic traits demonstrate a characteristic pattern of attenuated visual exploration that can be decomposed into specific component features at the oculomotor level. With regard to saccadic eye movements, research has documented reduced saccade amplitudes and shorter saccade durations in individuals with ASD - a pattern termed “saccade dysmetria” that results in spatially clustered fixations limiting the breadth of scene sampling (Bast et al., 2021a). Complementing these findings, studies in the general population using dimensional measures of autistic traits have found that higher trait levels are associated with reduced saccade frequency during naturalistic social interactions, such that individuals with elevated autistic traits make fewer and shorter saccades while viewing a conversation partner’s face (Vabalas & Freeth, 2016). With regard to fixation behavior, individuals with autism and high autistic traits tend to make fewer fixations overall, particularly to peripheral regions of faces and scenes, resulting in a “narrowed attentional spotlight” that over-focuses on central features at the expense of broader visual sampling (Robain et al., 2021; Snow et al., 2011). Difficulties in

disengaging attention from a current focus of interest have also been widely documented in individuals with ASD (for a review see [Sacrey et al., 2014](#)). Together, these findings converge on a profile characterized by reduced saccade amplitude, lower saccade frequency, and fewer fixations - collectively representing attenuated visual exploration that constrains the quality and quantity of social information available for downstream processing. Importantly, these oculomotor differences appear functionally related to social cognitive performance. For example, dynamic scanning between facial features correlates with face recognition accuracy in both individuals with autism and typically developing controls ([Wilson et al., 2012](#)).

Evidence that visual exploration is functionally linked to social cognitive performance comes from both group-based and dimensional approaches. In studies comparing individuals with and without autism, the relationship between fixation patterns and performance appears to differ between groups: [Snow et al. \(2011\)](#) found that the number of fixations during face encoding correlated with recognition memory accuracy in individuals with autism but not in neurotypical controls, while [Fedor et al. \(2018\)](#) observed that eye fixations predicted face recognition in typically developing individuals, whereas mouth fixations predicted recognition in individuals with autism – suggesting that the two groups rely on different scanning strategies to support face processing. Extending this work to a dimensional framework, [Davis et al. \(2017\)](#) provided the first direct evidence linking autistic trait dimensions to social cognitive performance via visual attention. Using subclusters of the Autism Spectrum Quotient (AQ) in the general population, they found that individuals scoring higher on the AQ Attention to Detail subscale made more fixations to the eyes, which in turn supported better face recognition accuracy. Together, these findings indicate that visual sampling serves as a functional bridge between individual characteristics and downstream social cognitive outcomes, though the specific mechanisms may differ across the autism spectrum.

The substantial heterogeneity in social cognitive performance among individuals with autism ([Bast et al., 2021b](#); [Jones et al., 2021](#)) suggests a more prominent role for visual exploration, where visual exploration itself may determine whether the effect of autistic traits on performance is expressed or attenuated. When visual exploration is efficient and comprehensive, individuals gather sufficient social information to support adequate performance, potentially buffering against autism-related deficits. Conversely, when visual exploration is restricted, the

impoverished input may exacerbate difficulties across the hierarchy of social cognitive processes.

An important consideration, however, is whether differences in basic visual processing abilities may confound the relationship between visual exploration and social cognition. Autism has been associated with atypical low-level visual processing, including altered texture integration and differences in perceptual organization (Hadad & Yashar, 2022; Pei et al., 2009). If basic visual abilities vary systematically with autistic traits, they could independently influence both visual exploration patterns and social cognitive performance, making it difficult to isolate the specific contribution of exploration efficiency. Previous studies examining visual exploration in autism have not typically incorporated measures of basic visual processing, leaving this potential issue unaddressed.

Despite growing evidence that visual exploration is functionally linked to social cognitive performance, whether visual exploration moderates the relationship between autistic traits and social cognition has not been directly tested. In addition, this question has not been examined across multiple levels of the social cognitive hierarchy simultaneously – from basic gaze detection to emotion recognition to theory of mind. Finally, the potential confounding influence of basic visual processing abilities has not been accounted for in studies examining visual exploration in autism.

The Present Study

The present study sought to examine the relationships among autistic traits, basic gaze detection, emotion recognition, and higher-level theory of mind abilities, while investigating the intervening role of visual exploration efficiency. Consistent with the dimensional conceptualization outlined above, we measured autistic traits as a continuous variable across all participants rather than comparing categorical diagnostic groups. The heterogeneity of the autistic phenotype underscores the limitations of traditional categorical approaches (Anderson, 2008), and a dimensional framework may be particularly suited to detecting subtle variations in social cognition that operate continuously across the population (Lombardo et al., 2019).

In our sample of individuals with varying levels of autistic traits, we assessed various social cognitive performance metrics: precision in the detection of gaze direction, emotion recognition, and complex social inference such as theory of mind using naturalistic video-based tasks. Additionally, we recorded eye movements during task performance to characterize

individual differences in visual exploration patterns. We hypothesized that elevated autistic traits would be associated with impairments across all levels of the social cognitive hierarchy - from basic gaze detection precision to emotion recognition to theory of mind accuracy. Crucially, we predicted that visual exploration efficiency would moderate these relationships, such that more efficient visual sampling would attenuate the association between autistic traits and social cognitive deficits. By examining both the hierarchical building blocks of social cognition and the visual sampling processes that provide their inputs, the current study aims to advance understanding of the mechanisms contributing to social cognitive difficulties across the autism spectrum.

Methods

Participants

Participants (N = 166; X female, X male) were recruited through clinical services, patient registries, social media, and community outreach initiatives. The recruitment strategy aimed to capture individuals across the full spectrum of autism traits and social functioning, ranging from neurotypical individuals to those with subclinical traits and mild social impairment to those meeting diagnostic criteria for autism spectrum disorder (ASD). This approach enabled dimensional analysis across the continuum of autistic features. The age range of 14-30 years was selected to examine a critical period of social development, avoiding confounds of early developmental changes or age-related decline. The minimum age of 14 years ensured at least 8th-grade language comprehension, allowing consistent use of assessment measures across the sample. All participants were fluent English speakers with normal or corrected-to-normal vision. Exclusion criteria comprised active substance use within 30 days prior to participation, IQ below 80, and presence of neurological or known Mendelian disorders. Four participants were excluded during data processing: one for failing to follow the directions correctly and three for responding randomly on the gaze detection task, yielding a final sample of 162 participants (see [Table 1-2](#) for demographic and psychometric characteristics). Written informed consent was obtained from adult participants or parents/legal guardians of minor participants, who provided assent.

Measures

Basic Visual Processing

To examine whether associations between autistic traits and social cognition might be attributable to individual differences in low-level vision, we assessed two components of basic visual processing: visual acuity and contrast sensitivity.

Visual Acuity. Visual clarity was measured using the Stanford Acuity Test (StAT), a computerized assessment requiring participants to identify the orientation of a tumbling “E” presented at progressively smaller sizes (Piech et al., 2020). Testing was conducted binocularly to ensure consistency with other visual assessments in the study battery.

Contrast Sensitivity. The ability to detect luminance differences was assessed using the Sloan Low Contrast Letter Set Book (Precision Vision, Woodstock, IL; see Figure 1). Participants read letter charts presented at seven contrast levels (100%, 25%, 10%, 5%, 2.5%, 1.25%, and 0.6%) from a distance of two meters. Each chart contained 12 rows of five Sloan letters, with letter size decreasing by 0.1 log units per row. Charts were administered in descending order of contrast, and testing for a given chart was terminated when participants failed to correctly identify any letters on a complete row (see Figure 1).

Performance on each chart was scored using the Logarithm of the Minimum Angle of Resolution (logMAR) system based on the number of letters correctly identified (Elliott, 2016). In logMAR notation, lower scores indicate superior performance (e.g., zero corresponds to Snellen 20/20). Contrast sensitivity was operationalized as the difference between logMAR scores on the 2.5% contrast chart and the 100% (full contrast) chart (Balcer et al., 2003). Larger difference scores indicate greater visual degradation at low contrast levels, reflecting poorer contrast sensitivity.

Autistic Traits

Autistic traits were assessed using three measures: (1) the Autism Diagnostic Observation Schedule, Second Edition (ADOS-2), an observational assessment administered by trained research staff (Lord et al., 2000); (2) the Autism Spectrum Quotient (AQ), a 50-item self-report measure of autistic traits in individuals 16 years and older (Baron-Cohen, Wheelwright, Skinner, et al., 2001); and (3) the Social Responsiveness Scale (SRS), a 65-item informant-rated measure of autism symptoms in real-world settings (Constantino & Gruber, 2012) (see Supplemental

Methods, Section 1.3.1, for full description of measures and administration procedures; see [Table 2](#) for score distributions).

Eye Gaze Perception Task

Gaze behavior and physiological responses during social perception were measured using a gaze detection paradigm adapted from Tso et al. (2012) and Blain et al. (2023) with concurrent eye-tracking measurement. This task enabled simultaneous recording of visual exploration patterns and behavioral measures.

Stimuli

Task stimuli consisted of 108 grayscale photographs of faces (three male, three female actors) from George et al. (2001). Each actor was presented in 18 images, systematically varying gaze angle from 0 degrees (direct) to 10 degrees (averted) in 1.25 degree increments, with left and right gaze orientations. All faces displayed neutral expressions. Example stimuli from one female actor are shown in [Figure 2](#). Images were presented using SR Research Experiment Builder software on a 23.8-inch LCD monitor (1920 x 1080 pixels). Face stimuli (480 x 645 pixels) were viewed from 550-600 mm, subtending approximately 15.1 degrees by 19.9 degrees of visual angle.

Task Design

Each trial consisted of a central fixation point positioned in the eye region for 500 ms, followed by blank screen for 100 ms, a face stimulus presentation for 2000 ms, and a final blank screen for 500 ms. Participants indicated whether each face was looking directly at them via button press at any point during the 2000 ms stimulus presentation. Face stimuli remained visible for the full duration regardless of response timing.

The task comprised four conditions administered in order of increasing difficulty: forward faces without noise, deviated faces without noise, forward faces with low noise, and forward faces with high noise. Each condition contained 108 trials (12 presentations per gaze angle), totaling 432 trials. Stimulus order within conditions was pseudorandomized and held constant across participants to prevent consecutive presentations of the same actor with different gaze angles or orientations, which could produce illusory motion effects. The current analyses focused on the forward-facing condition without noise to examine basic gaze perception and engagement patterns without the additional complexity of head deviation.

Perceptual Precision. Perceptual precision was assessed by fitting a logistic function to each participant's eye-contact endorsement data using Bayesian estimation with the `psignfit 4` MATLAB toolbox (Schütt et al., 2016). The model estimated two parameters in units of gaze “signal strength” (0-1 scale, where direct gaze maps to maximum signal strength): threshold (m) and width (w). The threshold parameter captures the observer's self-referential bias in judging whether gaze is directed at them, whereas width captures the precision with which different gaze angles are discriminated. Because gaze angles were transformed to a normalized “eye-contact signal strength” scale ranging from 0 (fully averted gaze at 10°) to 1 (direct gaze at 0°) to allow psychometric fitting on a common perceptual metric, both threshold and width are expressed in these signal-strength units. On this scale, lower thresholds reflect greater self-referential bias and narrower widths reflect higher perceptual precision. Further details on the derivation of these parameters are provided in the Supplemental Methods, Section 1.2, and Figure S1.

Reading the Mind in the Eyes Test

The Reading the Mind in the Eyes Test (RME) is a 36-item measure assessing theory of mind and emotion recognition from photographs of the eye region (Baron-Cohen, Wheelwright, Hill, et al., 2001). Participants select the mental state that best matches each image from four options, with higher scores indicating better performance (see Supplemental Methods, Section 1.3.2, for administration details; see Table 2 for score distributions).

The Awareness of Social Inference Test

The Awareness of Social Inference Test-Short (TASIT-S) assessed basic emotion recognition (Module 1) and theory of mind abilities (Modules 2 and 3) through brief video vignettes of social interactions (McDonald et al., 2006). Participants identified emotions and answered questions about characters' mental states (see Supplemental Methods, Section 1.3.3, for full description; see Table 2 for score distributions).

Eye Tracking Data Acquisition

Eye movements were recorded using an EyeLink 1000 eye tracker (SR Research) sampling at 500 Hz, tracking each participant's dominant eye. The system utilized pupil and corneal reflection (P-CR) tracking with a desktop-mounted camera. Participants were positioned 550-600 mm from the display (1920 x 1080 pixels, 60 Hz refresh rate), providing approximately 56 degrees horizontal and 33 degrees vertical field of view. Data acquisition was controlled by

EyeLink CL v5.15 software. Raw data were recorded in EDF format and subsequently converted to text files using SR Research proprietary software.

Eye Movement Data Processing

Data processing was performed in Matlab (version R2023b). Drift correction was applied using the mean eye position during the 150 ms pre-stimulus fixation period. Trials containing blinks or saccades during this baseline interval were excluded (X trials removed) as they precluded accurate drift correction.

Saccades. Saccades were identified using the EyeLink built-in event parser. Saccades occurring within 100 ms of a blink were excluded from analysis. Saccade amplitude was computed as the Euclidean distance between the start and end gaze positions of each saccade, converted from pixels to degrees of visual angle. Saccades with amplitudes smaller than 0.5 degrees were excluded following visual inspection of the amplitude distribution. Additionally, saccades with peak velocities exceeding 300 deg/s were identified as outliers and removed. Saccade rate was quantified as the number of saccades per second within each trial. For the pre-response interval, this was calculated by dividing the number of valid saccades occurring between stimulus onset and the participant's response by the reaction time (in seconds) for that trial. For the post-response interval, saccade rate was calculated by dividing the number of saccades occurring after the response by the remaining stimulus duration (2 s minus the reaction time). Trials with reaction times exceeding 1800 ms were excluded. Participant-level saccade rate and amplitude were obtained by averaging across valid trials.

Fixations. Fixations were identified using the EyeLink built-in event parser. Only fixations beginning after stimulus onset were included in the analysis. Fixations occurring within 100 ms of a blink were excluded, as were fixations with durations shorter than 100 ms or longer than 2000 ms. Fixation duration was defined as the time elapsed between fixation onset and offset as detected by the EyeLink parser, expressed in milliseconds. Fixation rate was quantified as the number of fixations per second within each trial. For the pre-response interval, this was calculated by dividing the number of valid fixations occurring between stimulus onset and the participant's response by the reaction time (in seconds) for that trial. For the post-response interval, fixation rate was calculated by dividing the number of fixations occurring after the response by the remaining stimulus duration (2 s minus the reaction time). As with saccade

metrics, trials with reaction times exceeding 1800 ms were excluded. Participant-level fixation rate and mean fixation duration were obtained by averaging across valid trials.

Statistical Analyses

Statistical analyses were conducted using R (version 4.3.0). To better conceptualize the diverse array of autism traits, a principal component analysis (PCA) was conducted to derive a single composite score (represented by the first principal component, explaining 42.2% of variance) for autistic traits using ADOS-2 subscales, AQ total score, and SRS total score as input variables (see Table S1; detailed methodology, including the treatment of missing values, is provided in Supplemental Methods, Section 1.3). To capture overall visual exploration patterns during gaze perception, a second PCA was conducted on four eye movement variables from the pre-decision period: saccade rate, fixation rate, fixation duration, and saccade amplitude. This analysis yielded a single “Visual Exploration” component (explaining 72% of variance) with high loadings from saccade rate and fixation rate (positive) and fixation duration (negative), capturing the tendency toward active visual scanning versus sustained fixation (see Table S3). Detailed methodology is provided in Supplemental Methods, Section 1.5. Basic visual processing was indexed by a composite of static visual acuity and contrast sensitivity (at 2.5% contrast), derived via PCA (first component explaining 58.3% of variance; detailed methodology, including the treatment of missing values, is provided in Supplemental Methods, Section 1.4).

To examine whether the expected association between autistic traits and reduced visual exploration was present in our sample, Pearson correlations were computed between autistic traits and visual exploration composites for both the pre-judgment (task-based) and post-judgment (free-viewing) periods. Pearson correlations were also computed among six core study variables: autistic traits, visual exploration, gaze perceptual precision (width), emotion recognition (RME), theory of mind (TASIT), and basic visual processing. To test whether visual exploration moderates the relationship between autistic traits and gaze perceptual precision, a multiple regression was conducted predicting perceptual width from autistic traits, visual exploration, and their interaction. Conditional effects of autistic traits on perceptual width were probed at low (-1 SD), mean, and high (+1 SD) levels of visual exploration. Given specific directional hypotheses regarding the relationships among study variables (e.g., that higher

autistic traits would be associated with decreased perceptual precision, and that visual exploration would improve performance), one-tailed tests were used for all primary analyses.

To test our theoretical model linking autistic traits to social cognition through gaze perception, structural equation modeling (SEM) was employed using the lavaan package in R (Rosseel, 2012). We specified a moderated serial mediation representing the hypothesized processing sequence: autistic traits → perceptual width → emotion recognition → theory of mind. Visual exploration was included as a moderator of the autistic traits → perceptual width path, and basic visual processing was included as a covariate predicting perceptual width. A direct path from autistic traits to emotion recognition was also estimated to test whether perceptual width partially or fully mediated this relationship. The interaction between autistic traits and visual exploration was computed as the product of standardized variables. This sequential ordering reflects developmental and theoretical accounts positioning emotion recognition as intermediate between low-level gaze perception and higher-level, contextually embedded theory of mind (Figure 5).

Model fit was evaluated using CFI (good ≥ 0.95), TLI (acceptable ≥ 0.90), RMSEA (good ≤ 0.06), SRMR (acceptable ≤ 0.08), and chi-square. Model parameters were estimated using full information maximum likelihood (FIML) with bias-corrected accelerated (BCa) bootstrap standard errors (5,000 resamples). Given the directional hypotheses, one-tailed tests were used for path coefficients and indirect effects. Conditional indirect effects were computed at low (-1 SD), mean, and high (+1 SD) levels of visual exploration. The Index of Moderated Mediation (IMM) tested whether the serial indirect effect varied as a function of visual exploration (Hayes & Little, 2018). Full versus partial mediation was assessed by testing whether adding a direct path from perceptual width to theory of mind (bypassing emotion recognition) significantly improved model fit. Model comparison was conducted between three nested models using AIC and likelihood ratio tests: a baseline model with no direct path from autistic traits to emotion recognition, a model adding this direct path, and a model additionally including a direct path from autistic traits to theory of mind. The most parsimonious model with adequate fit was retained. An alpha level of .05 was used for all statistical tests.

Results

Preliminary Analysis: Autistic Traits and Visual Exploration

Higher autistic traits were associated with reduced visual exploration during the free-viewing (post-judgment) period, $r = -0.14$, $p = 0.040$, consistent with prior literature linking elevated autistic traits to less active visual scanning of faces. During the task-based (pre-judgment) period, this association was not significant, $r = -0.05$, $p = 0.264$. Task-based visual exploration was used in all subsequent analyses because only exploration occurring before the gaze judgment can plausibly contribute to performance on the gaze detection task.

Bivariate Correlations

Pearson correlations among six core variables (Figure 3) revealed a pattern consistent with the hypothesized serial pathway. Higher autistic traits were associated with greater perceptual width (i.e., lower precision), $r = 0.17$, $p = 0.017$; greater perceptual width was in turn associated with poorer emotion recognition, $r = -0.39$, $p < .001$; and emotion recognition was positively associated with theory of mind, $r = 0.37$, $p < .001$, confirming each link in the proposed chain from autistic traits through gaze perception and emotion recognition to social inference.

Two additional predictors of perceptual width emerged: greater visual exploration was associated with narrower width (i.e., higher precision), $r = -0.17$, $p = 0.017$, and poorer basic visual processing was associated with greater width, $r = -0.19$, $p = 0.008$. Notably, autistic traits were also directly associated with both emotion recognition, $r = -0.23$, $p = 0.003$, and theory of mind, $r = -0.15$, $p = 0.030$, suggesting that the relationship between autistic traits and social cognition is not fully accounted for by perceptual precision alone. Basic visual processing was not directly associated with emotion recognition, $r = 0.03$, $p = 0.342$, or theory of mind, $r = -0.02$, $p = 0.400$, consistent with an indirect pathway through gaze perception.

Visual Exploration Moderates the Relationship Between Autistic Traits and Perceptual Precision

To test whether visual exploration moderated the link between autistic traits and perceptual precision, a multiple regression was performed predicting perceptual width from autistic traits, visual exploration, and their interaction. The overall model was significant, $F(3, 158) = 5.03$, $p = 0.002$, $R^2 = 0.087$. Autistic traits predicted perceptual width, $\beta = 0.075$, $t = 2.33$, $p = 0.010$, such that higher autistic traits were associated with greater width (i.e., lower

precision). Visual exploration also independently predicted perceptual width, $\beta = -0.088$, $t = -2.65$, $p = 0.004$. Critically, the autistic traits x visual exploration interaction was significant, $\beta = -0.085$, $t = -2.43$, $p = 0.008$, indicating that the strength of the association between autistic traits and perceptual precision depended on the degree of visual exploration.

Analyzing the interaction revealed that the relationship between autistic traits and perceptual width was significant at low (-1 SD) and mean levels of visual exploration, $\beta = 0.160$, $p < .001$, and $\beta = 0.075$, $p = 0.010$, respectively, but was attenuated and no longer significant at high (+1 SD) levels, $\beta = -0.010$, $p = 0.416$ (Figure 4). This pattern indicates that active visual exploration during the task can buffer the link between autistic traits and reduced gaze perceptual precision.

Moderated Serial Mediation

The moderated serial mediation model demonstrated good fit to the data, $\chi^2(8) = 3.50$, $p = 0.900$; CFI = 1.00; TLI = 1.14; RMSEA = 0.00, 90% CI [0.00, 0.04]; SRMR = 0.03. Path coefficients and model structure are depicted in Figure 5.

Within the structural model, the moderation of the autistic traits-precision link was confirmed. Autistic traits predicted perceptual width, $\beta = 0.17$, $p = 0.013$, and the autistic traits x visual exploration interaction remained significant, $\beta = -0.17$, $p = 0.022$. Consistent with the regression analysis, the conditional effect of autistic traits on perceptual width was significant at low (-1 SD) and mean levels of visual exploration, $\beta = 0.35$ and $\beta = 0.17$, respectively, but was attenuated at high (+1 SD) levels, $\beta = -0.01$. Visual exploration and basic visual processing also independently predicted perceptual width, $\beta = -0.20$, $p = 0.005$, and $\beta = -0.16$, $p = 0.019$, respectively.

Downstream in the model, perceptual width predicted emotion recognition, $\beta = -0.39$, $p < .001$, and emotion recognition in turn predicted theory of mind, $\beta = 0.37$, $p < .001$, supporting the hypothesized serial pathway from gaze perception through emotion recognition to social inference. A direct path from perceptual width to theory of mind (bypassing emotion recognition) was not significant, $\beta = -0.02$, $p = 0.788$, indicating that the effect of perceptual width on theory of mind was fully accounted for by emotion recognition.

Autistic traits also directly predicted emotion recognition, $\beta = -0.17$, $p = 0.002$, indicating that perceptual width only partially mediated this relationship. That is, autistic traits influenced

emotion recognition both indirectly through reduced gaze perceptual precision and through an additional pathway that did not depend on gaze perception.

To quantify the conditional indirect pathway, we examined the serial indirect effect of autistic traits on theory of mind (autistic traits \rightarrow perceptual width \rightarrow emotion recognition \rightarrow theory of mind) at each level of visual exploration. This effect was significant at low, estimate = -0.05, and mean levels, estimate = -0.02, but not at high levels of visual exploration, estimate = 0.00. The Index of Moderated Mediation confirmed that the serial indirect effect varied as a function of visual exploration, IMM = 0.03. The model accounted for 11.2% of variance in perceptual width, 20.5% in emotion recognition, and 13.8% in theory of mind.

Model Comparison

Model comparison among three nested models supported the inclusion of a direct path from autistic traits to emotion recognition. The baseline model (no direct paths) showed adequate fit, $\chi^2(9) = 8.68, p = 0.468$; CFI = 1.00; TLI = 1.01; RMSEA = 0.00, 90% CI [0.00, 0.09]; SRMR = 0.05; AIC = 3146.7. Adding the direct autistic traits \rightarrow emotion recognition path significantly improved fit, $\chi^2(8) = 3.50, p = 0.900$; CFI = 1.00; TLI = 1.14; RMSEA = 0.00, 90% CI [0.00, 0.04]; SRMR = 0.03; AIC = 3143.5; $\chi^2_{\text{diff}}(1) = 5.18, p = 0.023$. Further adding a direct path from autistic traits to theory of mind did not improve fit, $\chi^2(7) = 2.43, p = 0.932$; CFI = 1.00; TLI = 1.16; RMSEA = 0.00, 90% CI [0.00, 0.03]; SRMR = 0.02; AIC = 3144.4; $\chi^2_{\text{diff}}(1) = 1.07, p = 0.302$, supporting the more parsimonious model with only the direct autistic traits \rightarrow emotion recognition path.

Discussion

The present study examined the hierarchical relationships among autistic traits, gaze perceptual precision, emotion recognition, and theory of mind, and investigated whether visual exploration efficiency moderates these relationships. Three main findings emerged. First, visual exploration moderated the association between autistic traits and gaze perceptual precision, such that individuals with more active visual sampling showed an attenuated relationship between autistic traits and reduced precision. Second, a moderated serial mediation confirmed the hypothesized hierarchical cascade from autistic traits through gaze precision and emotion recognition to theory of mind, with visual exploration modulating the strength of this indirect pathway. Third, the model revealed two distinct pathways through which autistic traits influence social cognition: a perceptual pathway mediated by gaze precision and moderated by visual

exploration, and a direct pathway from autistic traits to emotion recognition that operates independently of visual exploration and gaze perception.

Visual Exploration Moderates the Link Between Autistic Traits and Gaze Precision

We hypothesized that visual exploration efficiency would moderate the relationship between autistic traits and social cognitive performance. Consistent with this prediction, the interaction between autistic traits and visual exploration significantly predicted gaze perceptual precision: at high levels of visual exploration (+1 SD), the association between autistic traits and reduced precision was attenuated and no longer significant, whereas at low and mean levels, higher autistic traits continued to predict poorer precision. This moderation was partial rather than complete, indicating that active visual sampling buffers against, but does not entirely eliminate, the effect of autistic traits on gaze detection accuracy.

This finding helps address the substantial heterogeneity in social cognitive performance observed among individuals with elevated autistic traits (Bast et al., 2021b; Hajdúk et al., 2022; Jones et al., 2021). Prior work has documented that some individuals with autism demonstrate normative performance on social cognitive tasks, while others show pronounced deficits, but the sources of this variability have remained poorly understood (Hajdúk et al., 2022). Our findings suggest that one source of this heterogeneity lies in individual differences in visual exploration. Individuals who engage in more active visual sampling – characterized by higher saccade and fixation rates, shorter fixation durations, and larger saccade amplitudes – appear to gather sufficient perceptual input to maintain adequate gaze detection performance, even in the presence of elevated autistic traits. Conversely, individuals who exhibit the attenuated visual exploration profile documented in prior research (Bast et al., 2021a; Snow et al., 2011; Vabalas & Freeth, 2016) may compound the effects of autistic traits by providing impoverished input to downstream perceptual processes.

The preliminary analysis further illuminated the nature of visual exploration in our sample. Higher autistic traits were associated with reduced visual exploration during the free-viewing (post-judgment) period, consistent with prior reports of reduced spontaneous visual scanning in autism (Jones et al., 2008; Klin et al., 2002; Pelphrey et al., 2002). However, this association was not significant during the task-based (pre-judgment) period, suggesting that task demands may promote more normative visual behavior – a pattern consistent with evidence that individuals with autism can modulate their looking behavior when task structure requires it

(DeStefani et al., 2026). The dissociation between task-based and free-viewing exploration is notable because it implies that the visual exploration captured during active task performance reflects genuine individual differences in sampling efficiency rather than a uniform impairment tied to autistic traits. It is this task-based exploration – the visual sampling that occurs while participants are actively making gaze judgments – that moderated the link between autistic traits and perceptual precision.

From Gaze Precision to Social Cognition

The structural equation model confirmed the hypothesized hierarchical organization of social cognitive processes (Adolphs, 2009; Stephenson et al., 2021). Gaze perceptual precision predicted emotion recognition, and emotion recognition in turn predicted theory of mind, establishing a serial pathway from basic perceptual discrimination to higher-order social inference. This sequential pattern is consistent with theoretical frameworks positioning gaze detection as a foundational social-perceptual skill that feeds forward into increasingly complex social judgments (Itier & Batty, 2009; Kleinke, 1986), and with proposals that disruptions at lower levels of the social cognitive hierarchy cascade upward to compromise higher-order processing (Happé & Frith, 2006).

A key finding was that the effect of gaze perceptual precision on theory of mind was fully mediated by emotion recognition. When a direct path from precision to theory of mind (bypassing emotion recognition) was tested, it was not significant, indicating that gaze precision influences complex social inference only through its contribution to emotion recognition. This pattern supports a genuine hierarchical architecture: gaze detection provides the perceptual input required for emotion recognition, which in turn provides the representational basis for theory of mind (Baron-Cohen, Wheelwright, Hill, et al., 2001; Penuelas-Calvo et al., 2019). Individuals who are less precise in discriminating gaze direction – and therefore less sensitive to the directional cues that convey attentional focus, emotional state, and social intent (Adams & Kleck, 2005; Liang et al., 2021; Servais et al., 2022) – show poorer emotion recognition from the eye region, which cascades into reduced accuracy on naturalistic social inference tasks that require integrating gaze, facial expression, and contextual information.

The moderation by visual exploration propagated through the full serial pathway. The conditional indirect effect of autistic traits on theory of mind through the hierarchy (autistic traits to precision to emotion recognition to theory of mind) was significant at low and mean levels of

visual exploration but not at high levels, and the Index of Moderated Mediation confirmed that the strength of this indirect pathway varied as a function of visual exploration. This result indicates that the buffering effect of active visual sampling is not confined to the initial perceptual stage but extends through the entire hierarchy of social cognitive processes. When visual exploration is sufficient, the cascade is effectively interrupted at its origin, preventing the downstream propagation of perceptual imprecision to emotion recognition and theory of mind.

Two Pathways and the Role of Basic Visual Processing

The model comparison supported the inclusion of a direct path from autistic traits to emotion recognition alongside the mediated pathway through gaze precision. This partial mediation indicates that autistic traits influence emotion recognition through two channels: an indirect, perceptual pathway that operates through gaze precision and is moderated by visual exploration, and a direct pathway that bypasses gaze perception entirely. The direct pathway may reflect non-perceptual mechanisms through which autistic traits affect social cognition, such as differences in social motivation (Chevallier et al., 2012) or in the allocation of cognitive resources to social information processing (Leekam, 2016). The social motivation theory of autism proposes that reduced orientation toward, seeking of, and pleasure from social stimuli may independently compromise the processing of emotional information, even when perceptual input is adequate (Chevallier et al., 2012). Our finding that autistic traits predict emotion recognition over and above their effect through gaze precision is consistent with this account and suggests that interventions targeting only the perceptual pathway may be insufficient to fully address emotion recognition difficulties.

An important contribution of the present study was accounting for basic visual processing in the model. Basic visual processing was indexed as a composite of visual acuity and contrast sensitivity, and significantly predicted gaze perceptual precision, confirming that low-level visual abilities contribute to performance on the gaze detection task. However, basic visual processing was not directly associated with emotion recognition or theory of mind. This pattern indicates that although basic visual abilities affect the perceptual gateway of the social cognitive hierarchy, they do not propagate further through the system. The social cognitive impairments associated with autistic traits are therefore not reducible to differences in low-level vision (Hadad & Yashar, 2022; Pei et al., 2009), a conclusion that strengthens the specificity of our model. This finding is notable given that previous studies examining visual exploration and

social cognition in autism have not typically controlled for basic visual processing, leaving open the possibility that apparent social-perceptual effects were driven by more fundamental visual differences.

Implications for Interventions

The finding that reduced gaze perceptual precision cascades through the social cognitive hierarchy underscores the clinical significance of impairments at this perceptual level. When individuals are less sensitive to subtle variations in gaze direction, they miss the directional cues that signal others' attentional focus and emotional state, and these missed signals propagate through the system to impair higher-order social inference. However, the moderation by visual exploration offers a potential counterpoint: it identifies visual sampling efficiency as a trainable factor that can buffer against this cascade, even among individuals with elevated autistic traits. The finding that the association between autistic traits and gaze precision was attenuated at high levels of visual exploration indicates a preserved capacity for adequate perceptual performance when visual input is sufficiently sampled, and this capacity could be leveraged in intervention.

Gaze-contingent paradigms are currently the most developed intervention approaches that are relevant to these findings. This type of interventions use participants' moment-to-moment eye position to modify the display in real time, so that looking at task-relevant regions is immediately reinforced or made more informative; they are therefore a natural way to target the visual sampling stage in our hierarchical model. These methods aim to shape how social information is collected, typically by increasing looks to faces or other diagnostic regions rather than by changing higher-level interpretive processes. For example, Wang et al. showed that gaze-contingent adaptive cueing in dynamic social scenes maintained and enhanced face-directed attention in young children with autism, preventing the within-session decline in social looking typically observed in this group (Wang et al., 2020). Related approaches that combine applied behavior analysis with gaze-contingent feedback have extended this framework to emotion-recognition training, rewarding children for directing gaze to informative facial regions during affect labeling tasks (Sosnowski et al., 2022). Within the tasks on which they are trained, such paradigms can increase the frequency and timing of gaze shifts toward socially informative cues and thus target the visual sampling component of our model, even though their effects on more general measures of disengagement or exploration have not yet been systematically quantified. A second type of interventions targets perceptual discrimination of faces and

emotions, which is more closely aligned with the perceptual precision component of the hierarchy in our framework. For instance, the “Let’s Face It!” program provides children with autism with ~20 hours of computerized games that train identity discrimination for faces; this yields significant improvements in face processing (Tanaka et al., 2010). Similarly, the Transporters program uses animated vehicles with embedded human emotional faces and has been shown to improve emotion recognition, with gains generalizing to novel faces (Golan et al., 2010). These perceptual training paradigms primarily act on the mapping from facial information to emotion categories, and so may strengthen the connection from gaze perceptual precision to emotion recognition, even though they do not explicitly manipulate eye-movement patterns. Overall, existing interventions that use eye tracking tend to focus on where individuals look (e.g., increasing fixations to faces, speeding initial orienting to social cues) rather than on core oculomotor parameters such as fixation length and latency of disengagement, saccade rate, or scanpath breadth. To our knowledge, there are no training protocols that explicitly and systematically target difficulties in visual disengagement or saccadic exploration as primary outcomes in autism. Designing gaze-contingent interventions that directly train more flexible disengagement and broader, more efficient scanpaths may be a promising direction for future work.

In addition, the two-pathway finding – that autistic traits influence emotion recognition through both a moderated perceptual route and a direct, non-perceptual route – implies that interventions targeting only the visual-perceptual channel may be insufficient to fully address social cognitive difficulties. Programs that address social motivation and engagement with emotional information may complement perceptual approaches by targeting the direct pathway from autistic traits to emotion recognition (Chevallier et al., 2012). A recent review of behavioral interventions for promoting social gaze in autism (Hustyi et al., 2023) identified approaches ranging from structured practice with reinforcement for directing gaze toward faces, to demonstrations of appropriate looking behavior followed by rehearsal, to technology-assisted methods using gaze-contingent feedback or interactive robots. These strategies span both motivational and behavioral mechanisms: some aim to increase the rewarding value of attending to social information, while others shape the looking behavior itself through repeated practice and feedback. Our two-pathway model suggests that a comprehensive intervention could pair

visual exploration training to address the perceptual pathway with social-motivational strategies to address the direct pathway from autistic traits to emotion recognition.

Limitations

Several limitations should be considered when interpreting these findings. First, although the sample spanned a wide range of autistic traits, the dimensional approach means that participants at the severe end of the autism spectrum were underrepresented. Future research using clinical samples stratified by severity level would help better define the current model.

Second, the serial mediation model is consistent with a causal cascade from gaze precision through emotion recognition to theory of mind, but the temporal ordering is inferred from theoretical and developmental accounts rather than from longitudinal evidence. Prospective studies tracking the development of these abilities over time would provide stronger support for the proposed architecture and could clarify whether interventions targeting earlier stages of the hierarchy (e.g., gaze precision) produce downstream improvements in later stages (e.g., theory of mind).

Third, the gaze detection task employed static face stimuli presented in a controlled laboratory setting, which may not fully capture the complexity of gaze processing in naturalistic social contexts. In real-world interactions, gaze direction is embedded in a complex stream of social information that includes head movements, facial expressions, body language, and overall social context (Birmingham et al., 2009a; Risko et al., 2016). Whether the moderation by visual exploration observed here extends to more ecologically valid settings remains an open question that future research employing dynamic or interactive paradigms could address.

Finally, the sample was drawn from adolescents and young adults aged 14-30, a period of ongoing social-cognitive development (Blakemore, 2012). The relationships among autistic traits, visual exploration, and social cognition may differ at other developmental stages, and the moderating role of visual exploration may be more or less pronounced depending on age-related changes in attentional control and social motivation (Fedor et al., 2018).

Conclusion

The present study provides evidence that visual exploration efficiency moderates the connection between autistic traits and gaze perceptual precision, and that this moderation propagates through a hierarchical cascade to shape emotion recognition and theory of mind. These findings advance understanding of the mechanisms contributing to social cognitive

difficulties across the autism spectrum by identifying visual exploration as a source of heterogeneity in social cognitive performance among individuals with elevated autistic traits. The two-pathway model – linking autistic traits to social cognition through both a perceptual channel moderated by visual exploration and a direct, non-perceptual channel – suggests that the origins of social cognitive impairment in autism are multifaceted and may require correspondingly a variety of approaches. Future longitudinal and intervention studies are needed to test whether enhancing visual exploration efficiency can improve social cognitive outcomes across the hierarchy and to identify the mechanisms underlying the direct pathway from autistic traits to emotion recognition.

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Appendix
Tables and Figures

Table 1*Demographic Characteristics of the Analysis Sample*

Variable	N	M	SD	Min	Max
Age					
All	162	23.2	4.4	14.0	30.0
14-17	17	15.4	1.2	14.0	17.0
18-25	87	21.6	2.4	18.0	25.0
26-30	58	27.8	1.5	26.0	30.0
Race					
White	115	71.0%			
Black or African American	9	5.6%			
Asian	28	17.3%			
More than one race	7	4.3%			
Other/NR	3	1.9%			
Sex (% Female)	162	66.7%			
Ethnicity (% Non-Hispanic)	162	92.0%			
Education (years)	162	14.9	3.0	8.0	23.0
Parental Education (years)	153	15.4	2.6	10.0	23.0
SES Score	162	2.5	0.9	1.0	5.0
FSIQ	162	113.8	12.3	80.0	144.0

Note. N = 162. Age groups, race, and ethnicity percentages are based on the full analysis sample. Parental education is the mean of both parents' education levels. SES = socioeconomic status; FSIQ = Full-Scale Intelligence Quotient.

Table 2*Descriptive Statistics for Psychometric and Task Measures*

Variable	N	M	SD	Min	Max
Autism Trait Measures					
AQ Total Score	149	25.4	9.8	4.0	47.0
SRS Total Score	119	59.2	34.9	2.0	147.0
Communication	160	1.0	1.3	0.0	6.0
Social Interaction	160	2.4	2.6	0.0	11.0
Creativity / Imagination	160	0.1	0.4	0.0	2.0
Stereotyped Interests / Restrictive Behaviors	159	0.8	1.2	0.0	6.0
Autism Traits Composite	162	-0.06	0.97	-1.70	2.99
Gaze Perception					
Gaze Precision (width)	162	0.92	0.42	0.27	2.36
Visual Exploration					
Visual Exploration - Task	162	-0.00	1.00	-2.70	2.22
Visual Exploration - Free-Viewing	162	0.00	1.00	-2.51	2.43
Social Cognition					
RME Total Correct	150	28.3	3.7	13.0	35.0
TASIT Accuracy	157	0.783	0.101	0.341	0.951
Basic Vision Processing					
Static Acuity (decimal)	150	1.69	0.53	0.67	3.33
Contrast Sensitivity (2.5% contrast)	147	0.37	0.11	0.14	0.80
Basic Visual Processing Composite	162	-0.00	1.09	-3.45	3.17

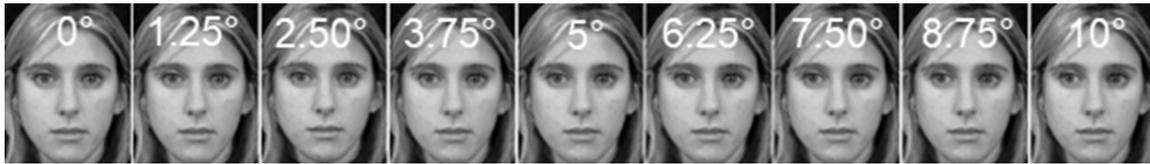
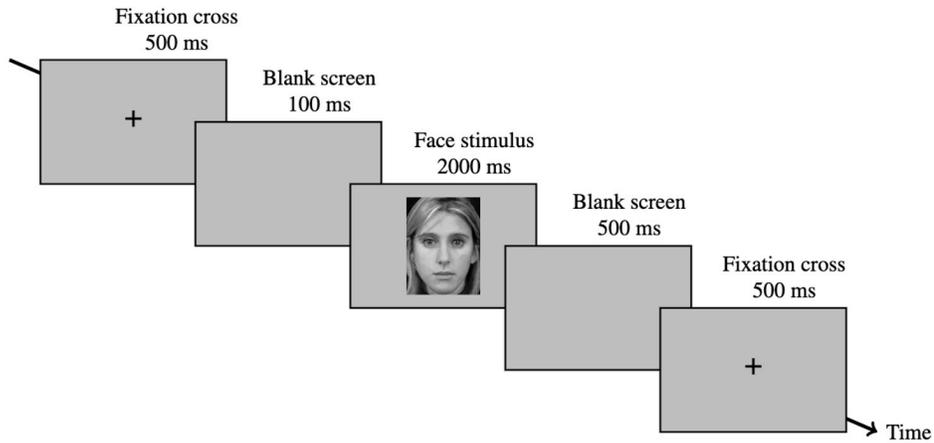
Note. N = 162. AQ = Autism Spectrum Quotient; SRS = Social Responsiveness Scale; ADOS = Autism Diagnostic Observation Schedule, 2nd Edition; RME = Reading the Mind in the Eyes Test; TASIT = The Awareness of Social Inference Test. Composite scores are standardized first principal component scores. ADOS subscales are indented under Self-Report Measures as they contribute to the Autism Traits Composite.

Figure 1*Sample Sloan Low Contrast Letter Chart*

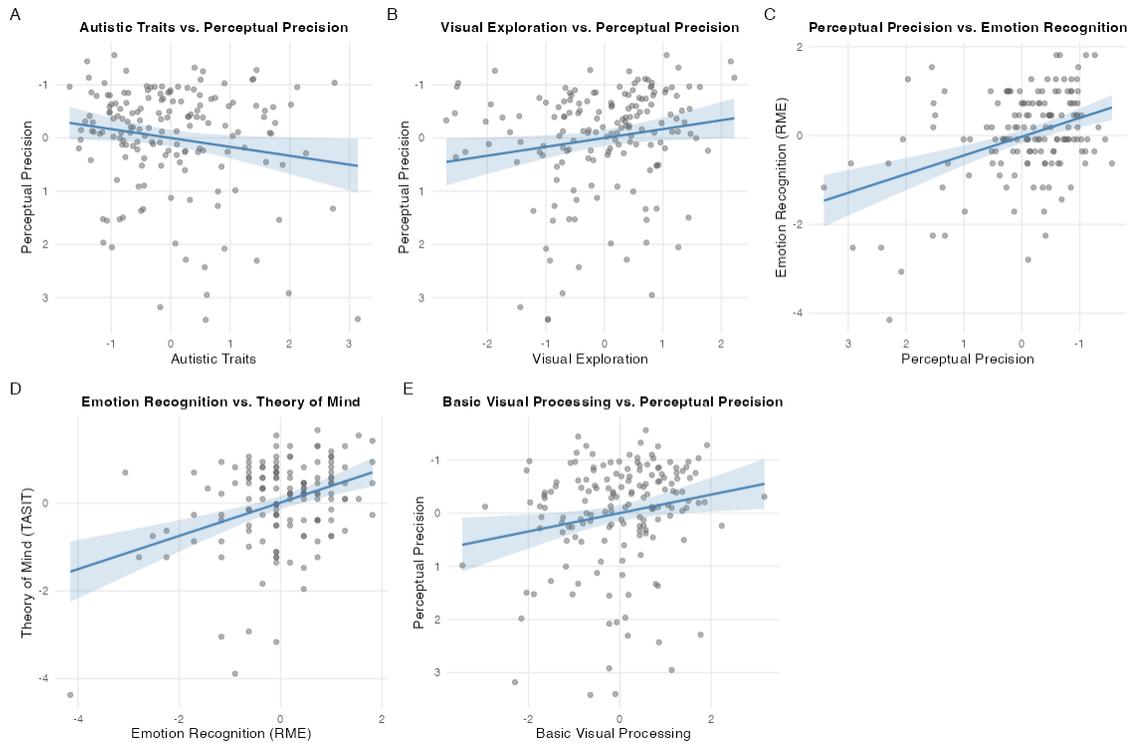
D V S H C	100% Contrast Level
D V S H C	25% Contrast Level
D V S H C	10% Contrast Level
D V S H C	5% Contrast Level
D V S H C	2.5% Contrast Level
D V S H C	1.25% Contrast Level
D V S H C	0.6% Contrast Level

Note. Sample Sloan Low Contrast Letter Chart used to assess contrast sensitivity.

Participants read letter charts at seven contrast levels (100%, 25%, 10%, 5%, 2.5%, 1.25%, and 0.6%) from a distance of two meters. Each chart contained 12 rows of five Sloan letters, with letter size decreasing by 0.1 log units per row.

Figure 2*Gaze Perception Task Stimuli***(A)****(B)****(C)**

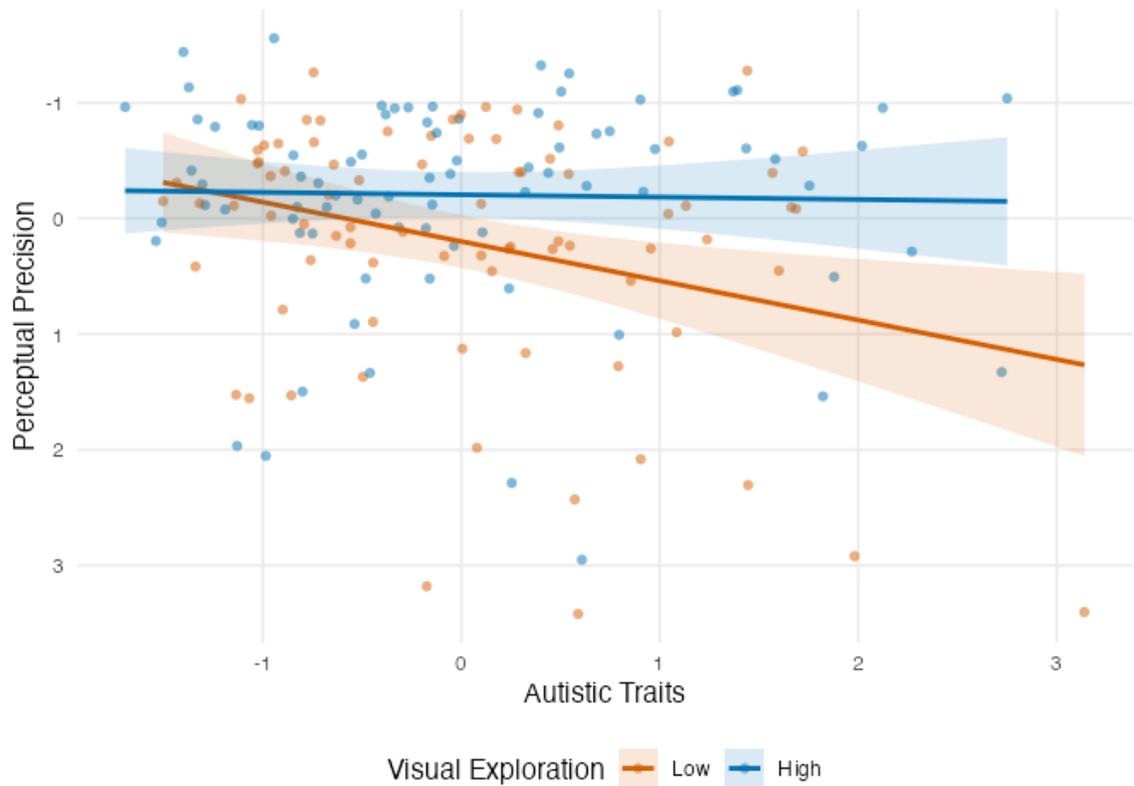
Note. (A) A stimulus example, with the gaze directed at the participant (gaze angle of 0°). (B) Face stimuli had 9 gaze angles, ranging from 0° (Direct eye contact) to 10° (Averted eye contact) in 1.25° increments. (C) Task stimulus timing.

Figure 3*Bivariate Scatterplots*

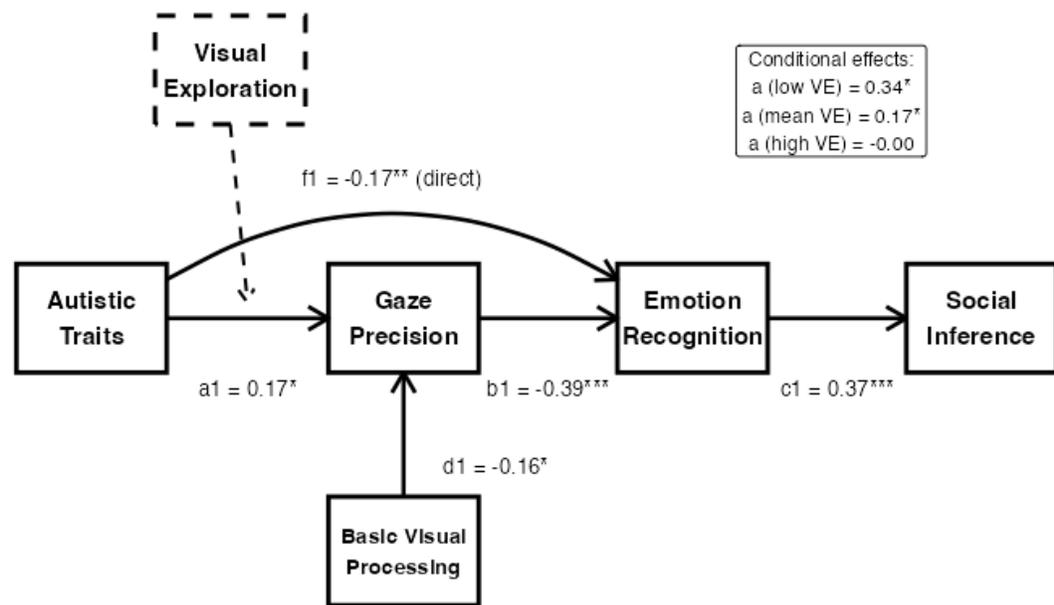
Note. The perceptual precision axis is inverted in panels A, B, C, and E because precision is measured as the width of the gaze performance curve, where larger values reflect less precise gaze perception. Reversing the axis ensures that higher positions correspond to better precision.

Figure 4

Relationship Between Autistic Traits and Perceptual Precision at Low and High Levels of Visual Exploration



Note. Scatter plot showing the relationship between autistic traits and perceptual precision at low and high levels of visual exploration. The precision axis is inverted because precision is indexed by the width of the gaze performance curve, where larger values indicate less accurate gaze perception; reversing the axis ensures that higher positions reflect better precision. Participants were split at the median of visual exploration for visualization; the statistical analysis treated visual exploration as a continuous moderator. Regression lines with 95% confidence bands are shown for each group.

Figure 5*Moderated Serial Mediation Model*

Note. Path coefficients are standardized betas. Perceptual width was indexed by the width of the psychometric function, where higher values indicate lower precision (i.e., greater difficulty discriminating gaze angles). The conditional a values show the effect of autistic traits on perceptual width at low (-1 SD), mean, and high (+1 SD) levels of visual exploration. Dashed box and arrow indicate the moderator variable. $*p < .05$, $**p < .01$, $***p < .001$.