Modeling Attention and Autism Characteristics in Repeated Measures of Social Gaze Perception

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Abstract

This study examined how autism diagnosis, attention problems, and adaptive functioning relate to social gaze behavior using a Stare-in-the-Crowd (SITC) eye-tracking task. Adult participants (18–35 years old) viewed 40 static and dynamic crowd images across four social conditions, each varying the gaze pattern of a single face within each scene. Autism diagnosis was associated with shorter second fixation durations and faster regression paths. The possible implications of a more selective visual scanning strategy. General attention problems were specifically associated with shorter second fixation durations, indicating less time spent maintaining gaze after detecting a change in social cues. Condition effects revealed that participants attended most when gaze shifted toward them mid-trial, reflecting sensitivity to dynamic, socially engaging cues across groups. Adaptive functioning, as measured by self-reported personal strengths, was unrelated to gaze behavior in this passive viewing context. These preliminary findings suggest that autism and attention-related characteristics may be associated with differences in how individuals allocate and maintain attention to socially meaningful information.

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Social-cognitive science researchers seek to understand not only how much individuals differ but also how—that is, both the quantitative magnitude and the qualitative nature — of group differences in social-cognitive processing. Quantitative differences may reflect variability in measurable outcomes, such as eye movements during reaction time or fixation duration during attention. In contrast, qualitative differences reflect variation in how underlying perceptual or attentional systems are structured, prioritized, and experienced differently across individuals or groups, even when quantitative metrics indicate similar levels of ability.

However, achieving both precision and generalizability is difficult. Laboratory paradigms that tightly control experimental variables enhance internal validity but often sacrifice ecological validity, limiting the extent to which findings translate to real-world social behavior. Conversely, tasks that approximate naturalistic settings increase external relevance but introduce additional variability that can obscure underlying mechanisms.

To explore these methodological and conceptual trade-offs, this study examines differences in gaze behavior using an eye-tracking paradigm previously used in the social gaze perception literature. In addition to asking whether diagnostic groups differ in gaze behavior, the study examines the types of differences that emerge to qualitatively describe patterns of variability across individuals. This approach yields a description of how clinical characteristics map onto differences in the organization and deployment of social attentional and perceptual processes underlying social cue interpretation.

Perceptual and Social Visual Systems

Human attention and perceptual systems have evolved to be sensitive to parsing social information, particularly from facial and gaze cues (Farroni et al., 2002; Stephenson et al., 2021). For example, when visually scanning a crowd, humans tend to focus on facial features and gaze direction to detect whether others are directing their attention toward potential danger in the environment (Ristic & Capozzi, 2022; Thompson et al., 2019). Humans primarily attend to faces during social interactions because facial expressions can provide critical information about others' internal states (e.g., emotions or location of attentional focus; Capozzi & Ristic, 2018). The ability to interpret these cues is essential for navigating environments, coordinating behavior with others, and forming social relationships, as it contributes to the development of neurocognitive systems underlying the motivation for prosocial behavior (Dalmaso et al., 2020). Humans' remarkable ability to detect others' gaze, compared to other species, reflects an evolutionary adaptation that supports complex communication and shared attention (Thompson et al., 2019). The bright white sclera in humans evolved as an adaptive trait that enhanced the visibility of gaze direction, which promoted group survival by signaling social engagement, threat, or cooperation (Kobayashi & Kohshima, 2001; Tomasello et al., 2007).

Neural circuits supporting visual perception and gaze interpretation connect perceptual and social systems, allowing individuals to read attention direction, emotion, and intention for action from eye movements. The dorsal visual stream, a neural pathway that begins in the primary visual cortex and projects to parietal regions, supports motion perception and spatial attention. This circuit processes "where" and "how" information about a scene and feeds forward to emotion-related regions to integrate subtle shifts in gaze direction and facial expression (Chien et al., 2016). The amygdala plays a part in heightening perceptual sensitivity to evaluate the emotional significance of another person's gaze (Adolphs et al., 1998; Hoffman et al., 2007). These circuits prioritize social gaze cues over other visual input, supporting efficient communication and social connection (For example, see Adolphs et al., 1998; Hoffman et al., 2007; Prior et al., 2022; Ramamoorthy, 2020; Stephenson et al., 2021).

Recent developmental neuroscience work underscores the importance of modeling individual variability rather than assuming uniform developmental trajectories. For example, Anandakumar et al. (2018) used resting-state functional connectivity analyses in a longitudinal sample of children and adolescents to examine whether individual differences in large-scale brain network organization predicted behavioral preferences in temporal decision-making. Rather than relying on age-based group comparisons, they applied multivariate modeling to show that patterns of functional connectivity explained variability in behavior that is typically attributed to chronological development. These findings support the conclusion that differences in neural organization provide a more precise account of behavioral diversity than age or diagnostic status alone. This analytic approach aligns with the current study’s goal of examining how individual variation in attentional regulation and adaptive functioning relates to social gaze behavior at the level of underlying cognitive processes rather than categorical group membership.

Gaze behavior is a critical entry point for studying how general visual attention and social cognition operate in tandem. Examining gaze behavior during the perception of social stimuli offers a direct lens into how individuals direct and sustain attention to socially relevant information, revealing both the mechanisms that support effective social understanding and the difficulties that can disrupt it. For this study, social gaze behavior refers to eye movements related to attentional orienting toward and perception of social information, such as patterns of how long and how often individuals look at socially relevant features, such as focusing on their social partner’s eyes.

Studying social gaze perception is important because strong evidence links gaze behaviors to social evaluation and appraisal (i.e., the interpretation of others' emotions, intentions, and social significance within an interaction; Capozzi & Kingstone, 2024; Dalmaso et al., 2020; Kendon, 1967). Poor eye contact modulation — i.e., inconsistent, minimal, or overly sustained gaze during communication — tends to lead to a negative impression from a social interaction partner, who may perceive the individual as disinterested, anxious, or socially unskilled. Maintaining appropriate eye contact during social interactions is associated with receiving impressions of attentiveness, intelligence, and pleasantness (Jaeger et al., 2022).

Measuring Social Visual Systems

One specific way to measure social perception is using eye tracking fixations. Fixations occur when the eyes briefly pause on a specific location, allowing information from that area of the visual field to be processed in detail. Attention and perceptual systems automatically modulate fixations and gaze patterns in response to cues related to task demands, relevance of social information, and social context to allocate cognitive resources (Borji & Itti, 2014; Palanica & Itier, 2012). Thus, fixation measurements will be used for the current study to assess how quickly participants orient their attention to and perceive socially relevant information (Tatler et al., 2010; Thompson et al., 2019; Yarbus, 1967).

Eye tracking provides researchers with a precise, noninvasive method for capturing patterns between higher-level social and lower-perceptual systems by recording fixations. It is particularly helpful for studying populations with sensory sensitivities. Its strengths include high temporal resolution and sensitivity to subtle perceptual differences that may not be captured by self-report or behavioral coding. However, it captures only overt visual attention and cannot fully represent the cognitive or affective components of social processing (Jongerius et al., 2020). The interpretation of results should therefore acknowledge that eye-tracking indices reflect one component of a broader perceptual–social system.

The Shared Attention System (SAS)

The shared attention system (SAS) provides a framework for understanding how gaze perception underpins higher-order social cognition, including theory of mind (also referred to as mentalizing, i.e., the ability to understand the mental states of others), which is essential for navigating complex social interactions (Mundy, 2018; Stephenson et al., 2021). Within the SAS, joint attention is the coordinated focus of two individuals on a shared object or event, linking perception and social understanding. Lower-level mechanisms, such as gaze direction detection, form the foundation for complex functions such as theory of mind and social bonding. While higher-level social systems shape how humans interpret gaze cues, lower-level visual mechanisms facilitate their detection.

General visual perception and attention help facilitate social attention and responsiveness. From a cognitive science perspective, attentional control over gaze reflects the interaction between domain-general executive processes and domain-specific social attention systems. General executive attention, commonly associated with the central executive component of working memory, supports goal maintenance, attentional shifting, and inhibitory control across contexts, including the regulation of visual orienting (Baddeley, 2000; Posner & Petersen, 1990). In contrast, social attention involves the selective prioritization and interpretation of socially relevant stimuli, such as faces and gaze direction, based on their communicative and interpersonal significance (Ristic & Capozzi, 2022; Stephenson et al., 2021). The SAS framework distinguishes these processes by situating gaze allocation as an interface between perceptual detection and social meaning-making. Executive attention governs the flexible control of attentional deployment

(Baddeley, 2000; Posner & Petersen, 1990), whereas the SAS integrates gaze cues with social context, learned expectations, and interpersonal goals (Mundy, 2018; Stephenson et al., 2021). Consequently, individual differences in gaze behavior may reflect variability not only in executive control capacity but also in how attentional resources are tuned to social relevance. This distinction is critical for understanding adaptive social functioning, as effective social engagement depends on the coordination of executive regulation with socially grounded attentional priorities rather than executive functioning alone. This study focuses on general executive attention by examining gaze behavior but also examines attention problems and adaptive social functioning skills in daily life to capture outcomes both related and unrelated to clinical diagnosis.

Maintaining eye contact activates multiple components of the SAS system by facilitating faster retrieval of socially relevant categorical information, such as recognizing emotion or intent (Macrae & Bodenhausen, 2000). Gaze-related cues, through attentional orienting toward another's line of sight and sustained engagement with social targets, enhance the accuracy of impression formation, the process of forming judgments about others based on observed cues (Capozzi & Kingstone, 2024; Dalmaso et al., 2020). Gaze direction shapes social judgments and group dynamics by modulating general executive attention to distribute visual perception cognitive resources across a scene and reinforcing the social significance of visual input (Chacón-Candia et al., 2023; Ristic & Capozzi, 2022).

The ability to detect and respond to gaze cues is not merely perceptual but also a core component of adaptive social functioning, supporting successful communication and relationship formation. Since social perception depends on the interaction between social gaze behaviors and general executive attention, variations in gaze patterns may indicate differences in underlying social-perceptual processes. Examining these differences can provide insight into how individuals allocate attention to socially meaningful stimuli and how these patterns relate to broader developmental trajectories.

Development of Shared Attention.

The SAS develops as gaze perception abilities scaffold increasingly complex social skills. The emergence of priming effects and positive perceptual biases toward social cues reflects a feedback loop in which early-developing skills shape the quality of interpersonal interactions. In turn, the affective outcomes of these interactions, whether positive or negative, contribute to the accumulation of social knowledge and influence how individuals approach future social encounters. Through this recursive process, social-perceptual and regulatory abilities are refined across development, supporting continued social skill development throughout childhood, adolescence (Anandakumar et al., 2018; Mundy, 2018; Vehlen et al., 2024), and adulthood (Jongerius et al., 2020; Stephenson et al., 2021).

Infants orient to direct gaze within the first months of life, and this ability quickly develops into joint attention behaviors that predict later language and social outcomes (Farroni et al., 2002; Mundy et al., 2007). Four-month-old infants exhibit a preference to orient attention to the eye contact of others (Farroni et al., 2002, 2004), which allows for the development of learned social responses, such as the ability to leverage eye contact and eye-gaze direction as a way to communicate information (Cook, 1977; Jongerius et al., 2020; Stephenson et al., 2021). Gaze-following abilities emerge at three to six months old (Farroni et al., 2004; Hood et al., 1998).

Joint attention typically develops across the first two years of life, initially emerging around five months of age, and is fundamental to adopting a shared perspective with another individual (Mundy, 2007, 2018). Mundy et al. (2007) examined the development of the SAS in infants aged 9-18 months, using tasks assessing eye contact with an interaction partner to initiate and coordinate gaze following and joint attention. They found that individual differences in joint attention were stable over time and significantly predicted language outcomes at 24 months, even after controlling for general cognitive development. Lack of eye contact in infants has been associated with neurodevelopmental delays and adverse mental health outcomes later in life (Armstrong & Olatunji, 2012; Milne, 2023).

Social visual perception and the SAS system are critical for developing social and attentional competencies, with individual differences in these processes influencing both strengths and challenges in social interactions. During middle childhood (approximately ages six to nine), children become increasingly adept at integrating gaze cues with contextual information, helping them navigate peer norms and group activities. By late childhood (ages 10-early adolescence), these skills support more advanced social cognition, including inferring others' mental states and adjusting behavior in response to gaze-based social cues (Buttelmann & Karbach, 2017; Stephenson et al., 2021).

In adolescence, sensitivity to peer gaze becomes especially important for social evaluation and identity formation. Social attention mechanisms undergo neural refinement, leading to greater sensitivity to peer gaze for social decision-making (Mundy, 2018). The increasing specialization of social-perceptual networks, particularly in the superior temporal sulcus and the medial prefrontal cortex, enables more complex processing of gaze direction and social context (Birmingham & Kingstone, 2009; Edwards et al., 2015; Emery, 2000; Kovacs-Balint et al., 2024). These developmental shifts shape how individuals engage with and interpret social cues, with variations in social attention contributing to differences in social adaptability and responsiveness (Stephenson et al., 2021).

As individuals transition into young adulthood, gaze behavior remains integral in joint attention, social bonding (Jongerius et al., 2020), and interpersonal coordination (Stephenson et al., 2021). Engaging in and responding to joint attention facilitates the development of social competence and adaptive functioning, such as forming peer, family, and romantic relationships and workplace communication (Ahlberg et al., 2023; Alaghband-rad et al., 2023; Armstrong & Olatunji, 2012; P. Wang et al., 2022).

Thus, over time, social gaze behavior forms a feedback loop in which early perception supports interpersonal interactions, and those interactions, in turn, refine social skill development through adolescence and adulthood (Anandakumar et al., 2018; Mundy, 2018; Stephenson et al., 2021). Variability in this feedback loop may explain individual differences in adaptive social outcomes.

Studying adults may capture outcomes of developmental variability in social and attentional networks. Whereas childhood studies emphasize skill acquisition, adult samples can reveal the degree to which sensory and attentional patterns translate into adaptive social skill outcomes or compensatory strategies. Young adulthood is a crucial period during which perceptual biases, such as reduced sensitivity to social gaze, persist or are modulated by experience and adaptive skills (Mundy, 2018; Stephenson et al., 2021). Examining gaze behavior in adulthood may provide insight into whether early neurodevelopmental differences persist as stable social-cognitive styles or diminish over time. In other words, it allows us to determine whether autistic adults without intellectual disabilities show patterns similar to nonautistic individuals.

The Stare-in-the-Crowd (SITC) Effect

Humans are especially attuned to noticing gaze directed toward them, which will be referred to as self-directed gaze (Farroni et al., 2002; Wang et al., 2021). Newborns as young as two to five days old can distinguish between direct and averted gaze, and by four months of age, infants exhibit increased neural processing during mutual gaze and a preference to attend to self-directed versus averted gaze (Farroni et al., 2002, 2004; Hood et al., 1998). Senju & Hasegawa (2005) examined how direct gaze captures visuospatial attention, demonstrating that individuals are more likely to allocate attention to faces that make direct eye contact. Their findings suggest that self-directed gaze enhances attentional orienting, likely because of its social significance in human interactions.

Visual search paradigms have demonstrated that individuals can rapidly and accurately detect when someone's gaze is directed at them from a crowd of faces, a phenomenon known as the Stare-in-the-Crowd (SITC) effect (Von Grünau & Anston, 1995). This ability is supported by the SAS, which integrates gaze detection, attentional shifts, and the evaluation of social relevance to support joint attention and communication (Capozzi & Ristic, 2018; Mundy, 2018; Stephenson et al., 2021).

The SAS engages a distributed neural network that overlaps with those implicated in the SITC effect. Key brain regions involved in this system include the superior temporal sulcus, which detects and interprets gaze direction (Edwards et al., 2015); the fusiform gyrus, which supports facial feature and identity processing; the amygdala, which assigns emotional and social salience to gaze cues; and the medial prefrontal cortex, which contributes to mental state attribution and perspective taking (Birmingham & Kingstone, 2009). These regions form a dynamic network linking low-level visual detection with higher-order social interpretation. Capozzi and Ristic (2018) describe this interaction as an (executive) attentional gating mechanism, through which gaze direction filters and prioritizes socially relevant information for further cognitive processing. The rapid recognition of direct gaze allows individuals to infer where another's attention is directed and to interpret its communicative intent, forming the basis for shared attention, learning social adaptive skills, and coordinating everyday interactions.

Gaze perception is not an isolated cognitive process but is shaped by environmental cues and prior expectations (Ramamoorthy et al., 2021). Accordingly, the efficiency of the SITC effect is influenced by contextual factors (Palanica & Itier, 2012) that adjust gaze perception in group contexts (Dalmaso et al., 2020). For instance, a direct gaze is more salient in contexts where eye contact signifies social engagement. In contrast, an averted gaze may capture attention when it signals an unexpected shift in focus (e.g., a face suddenly shifting from engaged to averted gaze and directing the eyes toward a new object in the environment). These findings emphasize the importance of using dynamic yet controlled paradigms.

To measure the dynamic nature of adapting and regulating eye contact in response to the SITC effect, Crehan & Althoff (2015) eye tracking was used to examine gaze patterns in undergraduate students while viewing dynamic versus stable images to capture gaze patterns during social perception. In their study, images of crowds in various settings were used to examine fixation time and patterns in response to changes in the self-directed gaze of a single face in the crowd. The images presented contained either all averted gazes, one person in the crowd looking at the participant, or one of two dynamic conditions. The gaze pattern of one face in the crowd, under dynamic conditions, simulated the participant getting caught staring at someone or catching someone else staring.

The SITC paradigm attempts to isolate the perceptual and attentional mechanisms involved in gaze detection by presenting participants with images of crowds in which one face either maintains or shifts gaze toward the observer. Detection of self-directed gaze within these visual arrays reflects both perceptual sensitivity to social cues and executive attentional control (interface of the SAS). The paradigm captures how individuals differentiate socially meaningful cues (such as direct gaze) from neutral ones and adapt their attention based on context. Although a simplified paradigm, it allowed the researchers to track subtle visual differences under controlled conditions and measure moment-to-moment social perception that underlies more complex, real-world social exchanges (Crehan & Althoff, 2015, 2021). The current study aims to link laboratory-based gaze-detection metrics to the social-adaptive capacities they support outside the lab.

Individual Differences in Gaze Perception

Differences in perceptual processes may affect how efficiently individuals orient to socially meaningful signals, especially in complex visual scenes with multiple faces competing for attention (Capozzi & Ristic, 2018). However, prevailing viewpoints disregard how personal strengths and social contextual affordances may lead to differing developmental trajectories within neurodivergent and subclinical populations.

Given that all individuals possess unique combinations of strengths and weaknesses, models of social perception must account for individual variability rather than relying on binary distinctions between clinical and non-clinical populations. Understanding these gradations gives a more nuanced perspective on how specific individuals develop alternative strategies for navigating social interactions.

Autism

Autistic individuals face challenges in engaging in shared social attention (Mundy, 2018). Diagnosis of autism spectrum conditions (ASC) typically includes identifying difficulties with non-verbal communication, including eye contact modulation (American Psychological Association, 2013). Gaze perception has been used to understand social-cognitive differences in autism and to clarify the extent to which gaze-perception difficulties stem from fundamental sensory differences versus contextual factors (Crehan & Althoff, 2021; Del Bianco et al., 2021; Falck-Ytter et al., 2023; Stagg et al., 2022). Autistic individuals often exhibit variability in gaze-based social processing, characterized by reduced attention to direct gaze in certain contexts but intact perception of gaze direction in others (Palmer et al., 2018; Ramamoorthy et al., 2021). Conflicting results in adapting social-cognitive paradigms for adult clinical populations suggest that prosocial skills and attentional differences may moderate gaze perception.

Recent work highlights that variability in gaze-based social processing among autistic individuals is shaped not only by perceptual sensitivity but also by the integration of emotional and contextual cues. Stagg et al. (2022) found that autistic adolescents could accurately identify emotions from static faces but had difficulty distinguishing genuine from feigned emotions in dynamic, context-rich scenes. This suggests that gaze and emotion recognition difficulties may stem less from basic perceptual limitations and more from challenges in integrating contextual and affective information when interpreting others' mental states. Such findings support the idea that social attention processes in autism are context-dependent, reflecting differences in how emotional meaning is extracted from gaze rather than a global deficit in face perception.

Social gaze patterns in autism and attention to faces have been a topic of debate in cognitive psychology for over a decade. Del Bianco et al. (2021) demonstrated that autistic individuals exhibit distinct temporal profiles of attention to faces, characterized by fewer returns to socially informative regions over time. Unlike neurotypical participants, who increasingly re-engage with faces across time, autistic participants maintained lower probabilities of returning gaze, suggesting delays in developing social expertise and sustained attention to social cues. These temporal differences indicate that gaze perception variability is not static but evolves across developmental trajectories that shape adaptive social learning.

Conversely, Falck-Ytter et al. (2023) argued that so-called “social attention” should not be viewed as a unitary deficit but as a multidimensional construct influenced by both domain-general attention and social motivation. They propose that atypical gaze behaviors may represent adaptive responses to differences in reward processing or motivation rather than primary perceptual impairments. Within this framework, gaze behavior in autism reflects alternative strategies for allocating cognitive and motivational resources. These authors posit the importance of interpreting social attention patterns qualitatively and attempting to connect them to context rather than with underspecified claims about “social attention” being uniformly diminished.

Crehan and Althoff (2021) also used their SITC paradigm in autistic and neurotypical adults. Their study found that autistic individuals exhibited reduced visual attention to self-directed gaze, particularly in dynamic conditions. Dynamic stimuli elicited more visual engagement than stable conditions, aligning with prior research suggesting that realistic visual stimuli enhance attentional responses (von dem Hagen & Bright, 2017). Research on autism, eye tracking, and emotion recognition has shown that dynamic gaze paradigms reveal subtle differences in gaze perception that may not be apparent in traditional static picture paradigms (Stagg et al., 2022).

For example, individuals with higher autistic traits demonstrate differences in attentional disengagement, which can affect how they process self-directed gaze in an SITC paradigm (Ramamoorthy et al., 2021). While the conventional view suggests that participant-directed gaze captures attention more strongly than averted gaze, findings from Ramamoorthy et al. (2021) challenge this assumption by demonstrating that attentional biases depend on the task context. Their study found that individuals with higher autistic traits exhibit an atypical attentional bias toward averted gaze when gaze uniqueness is highlighted. Gaze uniqueness refers to the distinctiveness of a particular gaze direction within a visual scene, especially when contrasted with surrounding gaze cues. In experimental paradigms, such as Crehan's SITC paradigm for measuring the SITC effect, gaze uniqueness is typically manipulated by presenting a single face with a different gaze direction among a group of faces that share the same gaze. This "odd-one-out" gaze stands out due to its contrast with the uniform gaze direction of the surrounding faces, drawing attention either because of its inherent social relevance (e.g., direct gaze signaling communicative intent) or due to its violation of an expected pattern (e.g., averted gaze disrupting a presumed norm). These findings on gaze uniqueness suggest that autistic individuals may rely less on direct-gaze priors and instead allocate attention to deviations from expected social cues, potentially altering how we interpret social visual search paradigm eye tracking studies.

Additionally, individual differences in executive attention allocation, such as hyperfocus on specific details or difficulty shifting attention, can contribute to variability in gaze cue responsiveness (Ristic & Capozzi, 2022). Pantelis & Kennedy (2017) deconstructed gaze perception into four fundamental components—precision, accuracy, spatial bias, and integration with contextual salience—to identify which aspects were atypical in autistic adults. They found that autistic participants showed greater variability in both precision and accuracy of gaze judgments, reflecting noisier or less consistent extraction of gaze direction information. While neurotypical participants exhibited a shared "butterfly" pattern of spatial bias centered on the vertical midline, many autistic individuals displayed idiosyncratic spatial patterns that diverged from this prototype. These individualized biases suggest that atypical gaze perception in autism arises from multiple underlying mechanisms rather than a uniform deficit.

Bayesian computational modeling provided the nuance that although both groups used contextual salience cues when judging gaze direction, autistic participants demonstrated broader variability in how much weight they assigned to these cues. Some participants over-relied on salient non-social elements, while others discounted contextual information altogether, leading to divergent visual attention allocation strategies. This heterogeneity aligns with other accounts of autistic perception as shaped by differences in prior weighting and predictive updating (Friston et al., 2013; Pellicano & Burr, 2012). Pantelis and Kennedy's (2017) findings emphasize that gaze processing in autism reflects diverse cognitive styles where some differences arise from perceptual noise and others in the calibration of expectations and contextual integration. These results underscore that social gaze differences in autism cannot be reduced to a single perceptual limitation. Instead, they reflect individualized profiles of precision, bias, and contextual weighting that interact with social motivation and attentional control. Such heterogeneity underscores the need for models that go beyond mean-group comparisons to examine within-person variability across multiple levels of analysis.

Other studies have challenged the idea that social interaction difficulties in autism stem solely from first-order perceptual differences, such as atypical gaze perception (Palmer et al., 2018). First-order perceptual differences refer to fundamental sensory processing abnormalities at the level of raw stimulus detection, such as difficulties in perceiving gaze direction due to impaired visual acuity or low-level contrast sensitivity. Palmer et al. (2018) provide evidence that autistic adults process gaze direction in a manner similar to non-autistic individuals, particularly in how they adjust their perception in response to visual input. One possible explanation for this study's findings is that autistic individuals rely less on learned expectations about gaze patterns, leading to greater variation in how they interpret where someone is looking and what that means in a social context. Individuals with high autistic traits have exhibited both increased and decreased sensitivity to gaze cues depending on the context, making it challenging to draw generalizable conclusions about gaze perception (Pell et al., 2016). However, these studies challenge the idea that fundamental sensory deficits cause differences in gaze perception in autism. Instead, they suggest that these differences may stem from how individuals interpret gaze cues rather than how they see them.

Rather than indicating fundamental sensory “deficits," these findings point to higher-order social cognitive processes, such as context-based interpretation and social learning, as key factors influencing social gaze behavior in autism. Autistic traits exist on a continuum within both clinical and non-clinical populations, influencing how individuals interpret gaze direction and social cues (Robinson et al., 2011). The variability in gaze perception observed in autistic adults highlights the heterogeneity of social differences within this diagnostic group. Over time, individuals accumulate diverse social experiences and develop adaptive strategies, resulting in more nuanced social perceptions and interactions. The current study expands these findings by comparing the variability accounted for by autistic symptoms with an alternative model examining executive attention problem outcomes, adaptive social functioning skills, and prosocial factors that may be associated with gaze patterns.

Attention Problems

Research on executive attentional mechanisms has demonstrated that multiple selection processes guide social attention. One is crowd-based selection, which prioritizes social cues based on a group's overall representation of social information rather than focusing on individual members or small-group interactions. This process enables individuals to extract and respond efficiently to the most consistent and dominant cues in large social settings (Ristic & Capozzi, 2022).

Predictive coding models of executive attention and visual perception suggest that gaze cues that violate expectations (e.g., an unexpected, averted gaze) can capture attention more strongly than typical direct gaze, especially when the task context highlights uniqueness (Ramamoorthy et al., 2021). Predictive coding models of attention suggest that the brain constantly generates expectations about incoming sensory input and devotes more resources to processing information that violates those expectations (Ramamoorthy, 2020; Ramamoorthy et al., 2021). In a typical social context, individuals expect to receive a direct gaze as an indication of interaction, making an averted gaze an unexpected and, therefore, more attention-grabbing cue when uniqueness is a defining feature of the task (Ramamoorthy et al., 2021). Recent SITC research (Crehan & Althoff, 2015, 2021) posits that direct gaze is not universally prioritized in visual search paradigms. Thus, the research on the SITC effect and eye tracking paradigms with clinical populations (Crehan & Althoff, 2021) should be expanded to look at executive attention outcomes and how that relates to context-dependent gaze capture.

Executive attention problems, such as difficulty sustaining or flexibly shifting attention, can alter how individuals allocate gaze in complex visual scenes (Birmingham & Kingstone, 2009; Dalrymple et al., 2020). Among individuals whose symptoms substantially interfere with daily functioning, those with a clinical diagnosis of attention-deficit disorder (ADD) or attention-deficit/hyperactivity disorder (ADHD) commonly exhibit difficulties with impulsivity and attentional regulation (American Psychological Association, 2013). Executive attention problems can lead to difficulties with learning, planning, self-organization, self-control, and behavior related to risk-taking and reward processing (Dalrymple et al., 2020). According to the Centers for Disease Control and Prevention (2016), ADHD is the most common neurodevelopmental disorder (NDD), affecting approximately 8.7% of children and adolescents globally and persisting into adulthood for 2.0 to 5.0% of the population (Staley, 2024). Attentional mechanisms that govern gaze perception are implicated in ADHD/ADD, where difficulties in sustaining and shifting attention may alter gaze-following behaviors and joint attention processes (Birmingham & Kingstone, 2009). Given that executive attention outcomes in adults play a prominent role in gaze behaviors related to the SITC effect under certain conditions (Ramamoorthy et al., 2021), exploring how these attention problems related to social gaze attentional orienting and perception can provide further insight into whether these outcomes are associated with social gaze behavior.

Heterogeneity Problem

There is no known universal etiology of ADHD/ADD or autism. There are also high rates of misdiagnosis, overdiagnosis, missed diagnosis, masking, comorbidity, and heterogeneity of behavioral presentations in both conditions (Astle & Fletcher-Watson, 2020; Martel et al., 2011, p. 201; Massuti et al., 2021; Nigg et al., 2020). Growing evidence suggests that there is a neural mechanistic and phenotypic heterogeneity problem within psychiatric characterizations of ADHD/ADD and autism that leads to weak etiological and clinical prediction signals and symptom instability into adulthood (Ahlberg et al., 2023; Bub, 2011; Nigg et al., 2020). The variability in gaze perception within adult autism and ADD/ADHD groups suggests that SAS difficulties may not stem from a series of core deficits but rather from differences in how attention is allocated based on social experiences and skills (Astle & Fletcher-Watson, 2020).

Attention problems are widely studied in children, particularly in relation to neurodevelopmental conditions; however, research on attention in adults remains limited. This gap is partly due to methodological challenges, as attentional developmental trajectories vary widely among individuals, making it difficult to establish universal patterns (Astle & Fletcher-Watson, 2020; Ilyka et al., 2024). Longitudinal studies suggest that executive attention difficulties in childhood do not always uniformly persist into adulthood, with some individuals developing compensatory adaptive social skills and others continuing to experience difficulties, particularly in isolation, due to difficulties with social relationships and behavior related to executive functioning and sustained attention difficulties (Ahlberg et al., 2023; Ilyka et al., 2024).

Moreover, conceptual issues arise from the assumption that attention deficits manifest similarly across the lifespan. Executive attention problems are often studied in children through structure tasks that assess distractibility, impulsivity, and hyperactivity. However, adult outcomes related to executive attention research must account for adaptive strategies and compensatory behaviors that emerge over time (Ilyka et al., 2024). For example, adults with ADHD may develop cognitive strategies that mask symptoms in specific contexts while still experiencing significant difficulties in unstructured or high-demand environments. Addressing these methodological and conceptual challenges requires nuanced approaches that incorporate individual variability and the influence of life experiences on executive attention regulation.

Many studies using diagnostic categories to examine executive attention and social development processes in clinical populations make two key assumptions that disregard inter-individual differences in adult transition skills and neuroplasticity during development (Shonkoff & Phillips, 2000). The first is that all cases of social attention or perception problems that arise in childhood are caused by and influence the development of internal mechanisms that can be pinpointed as the cause of all dysfunctional behaviors. There is growing evidence that the cognitive processes supporting executive attention and how it relates to life outcomes are distributed across a broad network of brain regions (Nigg et al., 2005, 2020).

Although much research has focused on children with executive attention and social differences and difficulties, similar attributes remain understudied in adults. A model of visual perception and SAS that accounts for variability in trajectories is needed to identify factors that promote improvements in social attention problem symptoms with age (Lin & Gau, 2019;

Willoughby, 2003). In addition, the phenotypic overlap in diagnostic profiles in current psychiatric classification systems for autism and ADD/ADHD supports the need for studies with transdiagnostic samples (Oh et al., 2021).

A Dimensional Framework for Executive Attention

There has been a shift toward dimensional symptom and skill modeling rather than a threshold or categorical approach when classifying cognitive processes to inform clinical and research endeavors (Anning et al., 2023; Vaidya et al., 2020). Transdiagnostic frameworks, such as the Research Domain Criteria (RDoC) from the National Institute of Mental Health, further emphasize mapping shared cognitive mechanisms across conditions to help identify neuropsychological and biological processes related to clinical psychopathological and neurodivergent presentations rather than separating "disorders" into discrete categories (Musser & Raiker, 2019; Nigg et al., 2020). The present study follows the RDoC framework, which emphasizes analyzing variation across dimensions of observable behavior and neurobiological mechanisms rather than dichotomous diagnostic categories (Insel et al., 2010). Within this framework, executive attention and adaptive social functioning are conceptualized as intersecting domains of cognitive control and social processing. This approach clarifies how individual differences in executive attention and adaptive social strengths, rather than diagnostic status alone, shape the mechanisms that drive variability in social gaze perception.

A complete understanding of social behavior and cognition cannot be achieved by focusing only on low-level neural processes and brain structures (Greenberg, 2011). Performance on visual perception and attention tasks can be shaped by distal processes, including mental and neurocognitive conditions, as well as proximal processes such as contextual variability and experiences throughout development (Ram et al., 2014).

The Role of Compensatory Qualities

Compensatory skills encompass the capacities that support successful daily living and social relationships, including prosocial behaviors, self-advocacy, and emotional regulation (Masten & Obradović, 2006). The current study will define adaptive social functioning skills by the presence of healthy and successful personal relationships (i.e., friendships, romantic partners, family connections), positive self-view (e.g., confidence, self-advocacy, responsibility), and prosocial behavior (e.g., honesty, enjoyment of social interactions, and helpfulness).

Recent work has emphasized that individual strengths, such as adaptive social functioning skills and prosocial behavior, may serve as protective factors that shape the interaction between general attention abilities and social systems (Dvorsky & Langberg, 2016; Masten & Obradović, 2006). Strength-based models, in contrast with pathology-oriented models, attempt to identify factors that facilitate positive developmental outcomes despite adversity and account for these skills as protective factors that buffer against difficulties (Dvorsky & Langberg, 2016). In adults, prosocial behaviors such as cooperation and empathy facilitate relationship maintenance and social cohesion and are associated with increased attention to socially relevant stimuli (Capozzi & Kingstone, 2024; Dalmaso et al., 2020; Vehlen et al., 2024). Thus, examining adaptive social functioning outcomes alongside executive attention problem outcome measures offers a more comprehensive view of how perceptual and social-cognitive skills interact to shape social engagement.

Visual systems may play a role in the development of adaptive social functioning skills. The SAS system allows humans to exchange intentions and other information and initiates an affiliative process (Stephenson et al., 2021). Affiliative processes refer to social behaviors and cognitive systems that promote connection, bonding, and cooperation between individuals. These processes include social bonding, empathy, mutual attentiveness, and shared intentionality, all of which contribute to successful interpersonal interactions.

However, there is a lack of research exploring how adaptive functioning specifically relates to social gaze behavior. Nguyen et al. (2025) examined adaptive functioning in children with cerebral or cortical visual impairment using standardized caregiver-report measures and found that poorer visual functioning was associated with lower adaptive functioning, particularly in domains related to socialization and daily living skills. Individuals with cortical visual impairment experience difficulties with visual search, navigating visually crowded environments, and recognizing faces or objects. Reduced visual ability, as measured by the Visual Behavior Scale, was correlated with lower scores in the socialization domain of the Vineland Adaptive Behavior Scale, which encompassed assessments of interpersonal relationships, play and leisure activities, and coping skills. The study suggests that children with better visual functioning tend to have stronger social interactions. Little research has been conducted in adults to understand how individual differences in visual-social attention and perception, rather than general visual abilities, are related to disparities in completing daily living tasks.

Social cohesion skills and relationships with family, peers, and colleagues are closely associated with gaze behavior. Research on gaze cueing suggests that individuals who actively contribute to their social groups, such as those who enjoy helping others and working collaboratively, are more likely to attract and direct their peers' attention (Dalmaso et al., 2020). Since shared attention is fundamental to social interactions, individuals more adept at directing their gaze when navigating complex social stimuli may also report stronger adaptive social functioning skill outcomes.

The Current Study

The current study will investigate the relationships among executive attention problem outcomes, adaptive social functioning outcomes, and social gaze perception in young adults. By employing SITC paradigms under both static and dynamic conditions, this research aims to parse individual differences in visual engagement and reaction time to self-directed gaze. Gaze perception is not uniform across individuals, and variations in executive attention regulation and social skills may influence how people detect, interpret, and respond with visual behavior to gaze cues (Ramamoorthy et al., 2021).

Research on the SAS and adaptive social functioning skills suggests that these variations emerge early in development and continue shaping social outcomes across the lifespan (Mundy, 2018; Stephenson et al., 2021). This study will examine variability attention problem and adaptive social skill outcomes in a transdiagnostic sample of individuals with no diagnoses, ADHD, autism, psychiatric conditions, and subclinical social-cognitive traits, to examine how social and attention outcome in adults modulate the ability to engage with and interpret self-directed gaze (Birmingham & Kingstone, 2009; Ristic & Capozzi, 2022). Previous research has shown that social responsiveness to gaze cues in crowds is influenced by individual prioritization of directed gaze (Capozzi & Ristic, 2018; Ramamoorthy, 2020; Ristic & Capozzi, 2022), contextual factors of the stimulus (Stagg et al., 2022; Vehlen et al., 2024), and clinical cognitive styles (Palmer et al., 2018; Ramamoorthy et al., 2021).

Participants viewed 40 images containing several young adults. The images were from one of four conditions depicted in Figure 1 and were intended to model gaze behaviors in social interactions within crowds. The first condition was *Stable Averted*, in which none of the gazes in the crowd were directed toward the participant. The second condition was a *Stable Participant-Directed* condition, in which one face in the crowd made eye contact with the participant. The third condition, *Delayed Averted,* simulates catching someone staring and is depicted in Figure 2. In the Delayed Averted condition, one face in the crowd shifts from participant-directed to averted when the participant fixates on an interest area (IA) programmed over the eyes of a person in each crowd image. Condition four will be called *Delayed Participant-Directed*, meant to mimic the participant getting caught staring at someone. During the display of an image in condition four, one face in the crowd shifts from averted to self-directed as participants' fixations are drawn to the IA.

Eye tracking was used to measure dwell time, fixation count, second fixation duration, and regression path duration for an IA on the eyes of one face per image. Dwell time reflected the total time a participant's gaze remained within the IA, indicating sustained visual engagement. Fixation count represented the number of discrete fixations within the IA, indexing the frequency with which attention was directed to that area. Second fixation duration measured how long the participant's gaze remained during the second fixation on the IA, providing an index of attentional re-engagement. Regression path duration captured the time required for the gaze to return to the IA after a glance away, reflecting the efficiency of visual search and reorientation processes.

Research Questions

1. How are executive attention problem outcomes related to perceiving and attending to averted versus directed gaze in static versus dynamic conditions of the SITC paradigm (Crehan & Althoff, 2015, 2021)?
2. Do adaptive social functioning outcomes, as defined by positive personal relationships and individual prosocial strengths, moderate the relationship between attention problems and social gaze behaviors?

3. How do the models of gaze behavior that incorporate executive attention problem outcomes and adaptive social functioning outcomes to account for the variability in gaze behaviors in the SITC paradigm compare to one that relies solely on using autism diagnosis to account for the variability in gaze behaviors?

Hypotheses

1. It was expected that the Stable Averted condition would show similar outcomes regardless of general attention problems in daily life or adaptive social functioning outcomes (Jording et al., 2018).
2. Based on prior research on gaze uniqueness and context (Crehan & Althoff, 2015, 2021; Palanica & Itier, 2012; Palmer et al., 2018; Pantelis & Kennedy, 2017; Pell et al., 2016; Ramamoorthy, 2020; Ramamoorthy et al., 2021), it was expected that higher attention problems, but not autism symptoms, would predict shorter dwell times and fewer fixations in the Stable Participant-Directed condition, and that both general attention problems and autism symptoms would relate to fewer fixations and shorter second-fixation durations in the dynamic conditions.
3. I hypothesized that self-reported attention problem outcomes and adaptive social functioning skills would better predict gaze behavior during the SITC task than autism symptoms alone (Nguyen et al., 2025; Ristic & Capozzi, 2022; Senju & Hasegawa, 2005; Stephenson et al., 2021).

Method

Data for the current study were collected as part of the Key Intimate Social Skills (KISS) Project. The KISS project aimed to test the feasibility of laboratory-based tasks in measuring the social skills needed for healthy romantic relationships in young adulthood. Participants were compensated $150 for completing the entire study. Funding for this research was provided by the National Institute of Health (R34 MH127065-01A1).

Participants

The sample included 127 young adults between the ages of 18 and 35 years (*M* = 20.78, *SD* = 3.12), who participated through Tufts University in Medford, Massachusetts, and Boston Children's Hospital in Boston, Massachusetts. The study was approved and overseen by the Boston Children's Hospital Institutional Review Board, and written informed consent was obtained from all participants prior to participation. All participants were screened for visual impairments, major underlying health conditions, and medications that could affect psychophysiological or oculomotor measurements. Autistic individuals with both a formal diagnosis from a physician or psychologist and those who self-identified as autistic were able to enroll in the study. Autistic characteristics were confirmed using the Autism Observation Schedule (ADOS), administered by trained researchers and clinicians. The sample demographics are presented in Table 1.

No significant differences in age or IQ were observed between participants with and without a formal autism diagnosis. The mean age did not differ significantly across groups, t(125) = 0.84, *p* = .404, indicating that age was not a confounding factor in the analyses. Gender diversity was more prominent among participants with autism: 28% of the ASD group identified as non-binary, transgender, or genderqueer, compared to 9% in the non-ASD group, $\chi^2(2, N = 127) = 7.42$, *p* = .024. This finding aligns with prior evidence that autistic populations exhibit greater gender diversity (Warrier et al., 2020).

Nonverbal intellectual functioning (FSIQ2) was evaluated. The Matrix Reasoning and Vocabulary subtests of the Wechsler Abbreviated Scale of Intelligence–Second Edition (WASI-II; Wechsler, 2011) were administered prior to the eye-tracking session to assess general cognitive ability. All participants met the inclusion criterion of a FSIQ2 score of 70 or higher, confirming that none met criteria for intellectual disability. FSIQ2 scores were examined for associations with autism measures but were not retained as a covariate in the final models. FSIQ2 was not significantly associated with gaze outcomes and did not meaningfully alter parameter estimates for attention or diagnostic predictors. The mean FSIQ2 score for the sample was 118.82 (*SD* = 12.70), indicating that, on average, the sample demonstrated above-average intellectual functioning, which should be considered when interpreting the generalizability of the findings.

Procedure

Participants completed a series of standardized neuropsychological assessments to characterize their clinical presentation, social skill outcomes, attention problems, and prosocial adaptive functioning prior to the eye-tracking task.

Achenbach Adult Self Report (ASR)

The Achenbach Adult Self-Report (ASR; Rescorla & Achenbach, 2004) was used to measure adaptive social functioning outcomes and attention problems in daily life. In the present study, adaptive social functioning skills were conceptualized as performance across friendship, romantic, and occupational social domains, as defined by the ASR, and as engagement in prosocial and affiliative behaviors that reflect social motivation and reciprocity. This conceptualization aligns with theoretical frameworks linking adaptive social skills to prosocial orientation and community participation, rather than to task-based competence alone (Dvorsky & Langberg, 2016; Masten & Obradović, 2006). Accordingly, self-reported adaptive (social) functioning in daily life was treated as a proxy for social engagement and participation capacity.

The ASR Adaptive (Social) Functioning domain included three primary competency scales: Friends, Spouse/Partner, and Job/Education. The Friends scale measured respondents' social relationships and the quality of their friendships. The Spouse/Partner scale assessed the quality of romantic relationships, when applicable, and the Job/Education scale measured performance and satisfaction in work or educational settings. Responses were scored on a Likert-type scale, with higher scores indicating greater adaptive functioning. Raw scores from these subscales were summed and converted to T-scores, normed by age and gender, with higher T-scores indicating stronger adaptive functioning.

In addition, the Personal Strengths Scale from the ASR was used to assess positive psychological and social attributes, including self-confidence, stress-coping, optimism about the future, and sense of purpose. This scale was derived from a subset of positively framed items and standardized to T-scores, with higher scores reflecting greater resilience and psychological well-being. The full list of questions for both scales is in the Appendix.

Autism Diagnostic Observation Schedule (ADOS)

Formal diagnosis status was compared with scores obtained from Module 4 of the Autism Diagnostic Observation Schedule (ADOS). This comparison will serve as a cross-validation measure, evaluating the consistency between formal diagnostic status and structured clinical observations of autistic traits. Module 4 of the ADOS is a standardized, semi-structured assessment designed for verbally fluent adolescents and adults to evaluate autism-related behaviors in communication, social interaction, and restricted or repetitive behaviors (Hus & Lord, 2014). Unlike other ADOS modules, Module 4 is tailored for individuals with complex, fluent speech, focusing on reciprocal social communication and behavioral features relevant to ASC.

Stare in the Crowd Eye Tracking

Following the clinical characterization visit, participants returned to the lab and were seated approximately 60 cm from a 24-inch stimulus monitor in a quiet, dimly lit testing room. Stimuli were presented on a *Dell OptiPlex* computer running SR Research Experiment Builder software and controlled remotely through a dedicated *EyeLink* Host PC. Eye movements were recorded using an *EyeLink 1000* Plus desktop-mounted eye-tracking system (SR Research Ltd., Ontario, Canada) sampling at 1000 Hz with a spatial resolution of 0.01° RMS and an average gaze position accuracy of 0.25°–0.5°. A 5-point calibration and validation procedure was conducted at the beginning of the session to map gaze position to screen coordinates. Calibration accuracy was verified before task onset, and additional validation checks were performed between blocks to ensure signal stability.

Following calibration, participants completed a 10-minute SITC task consisting of 40 experimental trials. Each trial presented a static crowd image containing multiple faces, with one face designated as the IA for eye-tracking analyses. Across stimuli, IAs were defined as oval regions tightly bounded around the eye area of the target face, with size varying naturally as a function of face scale and image composition. Based on the exported IA geometry, IA area ranged from approximately 264 to 7,045 pixels^2, with a median area of 1,826 pixels^2 ($M \approx 2,410$ pixels^2). IA width ranged from 26 to 145 pixels ($M \approx 78$ pixels), and IA height ranged from 12 to 69 pixels ($M \approx 35$ pixels). This variability reflects differences in target face size across images rather than inconsistency in IA definition, as IAs were consistently constrained to the eye region across all trials. By allowing IA dimensions to scale with the visual properties of each image, this approach preserved anatomical specificity while maintaining sensitivity to socially salient gaze cues. Figure 3 provides representative examples of crowd-based stimuli and illustrates the location, shape, and relative size of the IA across different image configurations.

This approach allowed gaze metrics to reflect attention to socially salient eye cues rather than broader face scanning. Stimuli were displayed for 4,500–12,000 milliseconds, depending on how long participants took to scan the image and fixate within the IA. Participants were instructed simply to “look at the screen” while the images were displayed. Between each image, a central fixation dot was presented for 500 milliseconds, followed by a brief validation check to ensure accurate gaze calibration throughout the session.

The system recorded over 100 measures of gaze behavior, including fixation location, fixation duration, saccades, blinks, and pupil diameter. IAs were defined around the target face in each of the 40 trials to facilitate comparisons of gaze allocation to eyes versus non-relevant regions. This approach provided a quantitative index of participants’ visual attention and perceptual processing during social scene viewing. Each participant viewed all 40 crowd images, presented one at a time in randomized order. Each image depicted a group of adults or college-aged peers and corresponded to one of four experimental conditions depicted in Figure 1.

In stable conditions, images remained static for 16 seconds; the eight-second midpoint was treated as the onset of a second phase to maintain analytic consistency. In dynamic conditions, the initial image was displayed for up to eight seconds or until the participant’s gaze crossed a predefined trigger boundary over the target face’s eyes, at which point a second version of the image appeared for the remainder of the trial (approximately eight seconds for participants who did not make eye contact). This design allowed examination of how participants oriented to and disengaged from gaze cues under stable versus changing visual images.

Gaze Data Processing

EyeLink data were parsed using *SR Research Data Viewer* (Version 5.12), which automatically computed fixation durations, saccade amplitudes, dwell time, and regression path durations. For each trial, fixation and saccade events were defined using the *EyeLink* default thresholds of 30°/s velocity and 8000°/s² acceleration. Fixations shorter than 80 milliseconds or longer than 1200 milliseconds were excluded as artifacts. Data were exported to a long-format trial-level file for subsequent statistical analyses in *IBM SPSS Statistics* (Version 29) and the *lme4* package in R.

Preliminary Analyses

Participants with average dwell time and second fixation duration scores more than three standard deviations from the mean were flagged for review to ensure that the measurements were plausible and not attributable to difficulty tracking gaze; however, no such scores were present in the sample. The means and SDs of the clinical and cognitive measures by autism diagnostic group are presented in Table 2. The resulting dataset contained 5,079 valid trials across 127 participants.

Log Transformations for Gaze Times

All continuous gaze behavior dependent variables, dwell time, fixation count, second fixation duration, and regression path duration, were inspected for normality prior to analysis. Each measure exhibited positive skew typical of reaction time and gaze-based data, with long right tails reflecting occasional extended fixations. For example, raw dwell times ranged from 0 to 4,058 ms ($M = 354.52$, $SD = 652.24$, skewness = 2.46, kurtosis = 6.61), and second fixation durations ranged from 0 to 3,374 ms ($M = 92.31$, $SD = 260.37$, skewness = 4.75, kurtosis = 32.63). Similarly, fixation count and regression path duration showed moderate to high skew (skewness = 2.23–2.42).

All four dependent variables were therefore log-transformed to correct for non-normality. Following transformation, distributions approximated normality, with substantially reduced skewness and kurtosis (skewness < 0.6; kurtosis ≈ −1.6 to 0.1). These transformations are standard in reaction-time and eye-tracking analyses, as gaze-based latency measures often exhibit right-skewed distributions due to the probabilistic nature of attentional allocation (Baayen & Milin, 2010; Whelan, 2008). Participant-level and image-level trial data were then merged in long format, with each row representing a single trial nested within a participant and image ID.

Sex Differences

Sex differences in gaze behavior were evaluated to determine whether sex should be included as a covariate in the multilevel models. A series of independent-samples *t*-tests were conducted to compare biological sex across all primary dependent variables (log-transformed dwell time, fixation count, second fixation duration, and regression path duration). No significant differences emerged across sex groups (all ps > .10), indicating that gaze measures did not vary systematically by sex. Given the absence of significant effects, sex was not included as a covariate in subsequent models.

Assessment of Multicollinearity Among Adaptive Functioning Variables

Prior to hypothesis testing, correlations among predictor variables were examined to assess potential multicollinearity. The Achenbach Adult Self-Report (ASR) Mean Adaptive T-score and Personal Strengths T-score were highly correlated ($r = .82$, $p < .001$). Variance inflation factor (VIF) values exceeded acceptable thresholds for collinearity (VIF > 5), indicating that including both predictors in the same model would produce redundant and unstable parameter estimates. The Personal Strengths T-score was retained as the more theoretically comprehensive construct, encompassing prosocial engagement, resilience, and optimism, since the Mean Adaptive T-score primarily reflected domain-specific competence in friendships, romantic relationships, and occupational or educational settings. Retaining the Personal Strengths T-score improved model interpretability and parsimony, aligning with the study's conceptual emphasis on adaptive strengths as an indicator of social motivation and functional well-being.

Comparing Formal Diagnosis and ADOS Classification

To have multiple indicators of autism characteristics in this diverse sample, two Level-2 predictors were evaluated separately: ASD formal diagnosis (binary: yes/no) and ADOS_Met (binary: met/not met). However, the formal diagnosis model provided a substantially better fit than the empty model used for the continuous variables (−2LL = 13,965.1) than the ADOS classification model (−2LL = 31,489.8). A likelihood ratio test confirmed that the formal diagnosis model fit the data significantly better, Δ−2LL = 17,524.7, $\chi^2(1) = 17{,}524.7$, $p < .001$. This model also accounted for a greater proportion of residual variance (conditional $R^2 = .304$) than the ADOS model ($R^2 = .357$). Fixed effects further supported this difference:

- Formal Diagnosis: $\beta = -0.121$, *SE* = 0.026, F(1, 54.1) = 21.49, $p < .001$
- ADOS Met (yes/no): $\beta = 0.041$, *SE* = 0.023, F(1, 126.7) = 2.55, $p = .079$

Diagnostic Group Differences in Adaptive Functioning and Personal Strengths

Descriptive statistics for continuous predictors and gaze-behavior outcomes are shown in Table 3. A one-way analysis of variance (ANOVA) examined whether mean adaptive (social skill) functioning and personal strengths scores on the ASR differed across ASD formal diagnostic and ADOS criteria groups.

Results indicated a significant positive association between the non-autistic group and Personal Strengths T-scores, $F(2, 119) = 4.97$, $p = .008$, $\eta^2 = .08$, and Mean Adaptive T-scores, $F(2, 119) = 11.88$, $p < .001$, $\eta^2 = .17$. Bonferroni-corrected post hoc tests revealed that participants with no diagnosis (*M* = 51.54, *SD* = 7.55) had significantly higher Personal Strengths scores than those who met ADOS criteria without a formal diagnosis (*M* = 46.55, *SD* = 8.48), $p = .024$. Similarly, participants without a diagnosis (*M* = 51.92, *SD* = 7.66) scored higher in Mean Adaptive functioning than those with a formal ASD diagnosis (*M* = 46.93, *SD* = 8.47), $p < .001$. Levene's tests confirmed equality of variances for both variables (*ps* > .30).

Parallel analyses using ADOS_Met classification (0 = non-spectrum, 1 = on the autism spectrum, 2 = autism) also revealed significant group effects for Personal Strengths, $F(2, 119) = 5.71$, $p = .004$, $\eta^2 = .09$, and Mean Adaptive Functioning, $F(2, 119) = 7.87$, $p < .001$, $\eta^2 = .12$. Bonferroni comparisons indicated that non-spectrum participants ($M = 51.40$, $SD = 7.42$) reported significantly higher Personal Strengths than autistic participants ($M = 46.48$, $SD = 8.49$), $p = .012$. A similar pattern emerged for adaptive social functioning between non-autistic ($M = 51.21$) and autistic ($M = 46.00$) participants, $p = .004$. These findings suggest that autism diagnostic classification, both by clinical record and ADOS score, is associated with lower self-reported adaptive and strength-based functioning relative to young adults without autism diagnoses.

Results

All analyses of continuous outcomes were conducted using cross-classified linear mixed-effects models (LMMs) to account for both participant-level and image-level effects. Both variables were entered into three identical cross-classified models predicting log-transformed dwell time, regression path duration, and second fixation duration, each controlling for condition and including random intercepts for participant and image. A Negative Binomial Generalized Linear Mixed-Effects Model (GLMM) was used for fixation count.

Trials (t) were cross-classified within participants (j) and images (i), allowing random intercepts for each level. A summary of outcomes is presented in Table 5. Each dependent variable was modeled using the general form:

$$Y_{tij} = \beta_0 + \beta_1(Condition)_{tij} + \beta_2(Attention)_j + \beta_3(Autism_j) + u_{0j} + v_{0i} + e_{tij}$$

where

- $Y_{tij} =$ the outcome (e.g., log-transformed dependent variable) for trial t, image i, and participant j

- β_0 = overall intercept (grand mean)
- β_1= fixed-effect coefficients for image condition (i.e., Stable Averted, stabled directed, Delayed Averted, or Delayed Participant-Directed).
- β_2 = fixed-effect coefficients for attention problems (continuous predictor).
- β_3 = Autism as indicated by either an ASD or autism classification on the ADOS or formal diagnosis of autism.
- u_{0j}= random intercept for participant j
- v_{0i}= random intercept for image i
- e_{tij}= residual (trial-level) error
- Moderation and mediation effects were also examined to test whether autism diagnosis, adaptive (social) functioning, or attention problems in daily life changed the relationship between another predictor and gaze behavior. However, these interaction terms were not retained in the final models because they did not significantly improve model fit or account for additional variance in any of the gaze measures. Given the limited explanatory contribution due to small sample size and to maintain model parsimony, moderation effects were excluded from the reported analyses.

All models were estimated using restricted maximum likelihood (REML) and compared using likelihood ratio tests (LRTs) based on the −2 log-likelihood (−2LL), with smaller values indicating better fit. Fixed effects were tested using Type III Wald F-tests with Kenward–Roger degrees of freedom correction. The reference category for all condition effects was Stable Averted, as it contained no self-directed gaze. Each dependent variable (log-transformed IA dwell time, IA second fixation duration, and IA fixation count) was analyzed in separate models. Condition (Stable Averted, Stable Participant-Directed, Delayed Averted, Delayed Participant-Directed) was treated as a within-subject categorical predictor, with Stable Averted as the reference group. Between-subject predictors included the ASR Attention Problems T-Scores, Personal Strengths T-Scores, and categorical ASD Formal Diagnosis.

Dwell Time

Dwell time refers to the total duration that participants spend fixating on the IA, the eyes of a face in the crowd. It reflects sustained visual engagement and the maintenance of attention once a target has been detected.

Empty Model.

A cross-classified random-intercepts model provided the best-fitting baseline structure. The full empty model (−2LL = 31,779.66) fit significantly better than the error-only model, $\chi^2(2) = 1{,}579.69$, $p < .001$. Adding participant-level random intercepts improved fit relative to the image-only model, $\chi^2(1) = 801.34$, $p < .001$, and adding image-level intercepts improved fit relative to the participant-only model, $\chi^2(1) = 1{,}126.92$, $p < .001$. Variance partitioning indicated that 14.5% of the total variance was attributable to participants, 19.2% to images, and 66.3% to trial-level residual error.

Model 1: Condition

Adding gaze condition improved model fit relative to the empty model (−2LL = 31,766.55; Δ−2LL = 13.11, $p < .001$, $\chi^2(3) = 43$). However, no pairwise condition differences reached significance after correction (all ps > .05). Variance partitioning remained stable (participants = 14.5%, images = 19.0%, residual = 66.5%). The condition-only model served as the baseline for subsequent comparisons.

Model 2: Attention Problems

Including Attention Problems T-score significantly improved fit relative to the condition-only model (−2LL = 31,030.45; Δ−2LL = 736.10, *p* < .001). The overall effect of attention problems was not significant, F(1, 121.98) = 2.27, *p* = .14, with a negative unstandardized estimate (β = −0.04, SE = 0.03), indicating that higher attention problem scores were associated with shorter dwell times. The effect of condition remained nonsignificant, F(3, 89.60) = 1.72, *p* = .165. Variance partitioning indicated that 14.7% of the variance was attributable to participants, 19.1% to images, and 66.2% to residual error.

Model 3: Autism Diagnosis

Adding ASD Formal Diagnosis did not significantly improve fit relative to the attention-only model (−2LL = 31,017.70; Δ−2LL = 12.75, p = .17). The effect of autism diagnosis was nonsignificant, F(1, 50.02) = 0.09, *p* = .76, as was condition, F(3, 95.05) = 0.54, *p* = .66. Variance partitioning was similar to previous models (participants = 13.0%, images = 17.0%, residual = 70.0%).

Model 4: Combined Model (Attention + Autism Diagnosis).

When both Attention Problems and ASD Formal Diagnosis were entered together, the model did not significantly improve fit (−2LL = 13,230.22). None of the fixed effects were significant. Condition was not a significant predictor, F(3, 95.05) = 0.54, *p* = .66. Autism diagnosis was not significant, F(1, 50.02) = 0.09, *p* = .76, and Attention Problems were also not significant, F(1, 50.02) = 0.00, *p* = .96. Variance partitioning indicated that 13.0% of variance was attributable to participants, 17.0% to images, and 70.0% to residual trial-level error. All random effects remained significant (Wald Z > 3.5, p < .001).

Regression Path Duration

Regression path duration denotes the time required for participants to refixate on a target face after initially looking away. It serves as an index of attentional reengagement, indicating how efficiently participants redirect their attention to previously attended social targets.

Empty Model

A cross-classified random-intercepts model provided the best-fitting baseline structure. The full empty model (−2LL = 15,920.75) fit significantly better than the error-only model, $\chi^2(2) = 1{,}832.48$, $p < .001$. Adding participant-level random intercepts significantly improved fit relative to the image-only model, $\chi^2(1) = 755.97$, $p < .001$, and adding image-level intercepts improved fit compared to the participant-only model, $\chi^2(1) = 1{,}311.59$, $p < .001$. Variance partitioning indicated that 15.0% of variance was attributable to participants, 20.7% to images, and 64.3% to residual trial-level error.

Model 1: Condition

Adding condition did not significantly improve model fit compared to the empty model, $\chi^2(3) = 5.77$, $p = .123$. However, pairwise comparisons indicated that regression path duration was significantly lower in the stable averted condition ($M = 0.93$, $SE = 0.18$) compared to the delayed participant-directed condition ($M = 1.15$, $SE = 0.18$), $p = .001$. The estimated mean difference was −0.23 ($SE = 0.07$, 95% CI [−0.36, −0.09]), suggesting less time spent re-fixating to the interest area in the Stable Averted condition. Variance partitioning remained similar (participants = 14.8%, images = 21.8%, residual = 63.4%).

Model 2: Attention Problems

Including Attention Problems T-score as a participant-level predictor significantly improved model fit relative to the condition-only model, $\Delta{-2LL} = 352.93$, $p < .001$. Attention problems were not a significant predictor of regression path duration, $F(1, 121.00) = 2.92$, $p = .09$.

The effect of condition remained significant, F(3, 89.46) = 4.48, *p* = .006. Variance partitioning indicated that 14.8% of the remaining variance was attributable to participants, 20.8% to images, and 64.4% to residual error.

Model 3: Autism Diagnosis

Adding ASD Formal Diagnosis significantly improved model fit relative to the attention-only model, Δ−2LL = 130.49, *p* < .001. The main effect of condition remained significant, F(3, 89.46) = 4.48, *p* = .006, and autism diagnosis was a significant predictor of regression path duration, F(1, 54.20) = 18.93, *p* < .001. Participants with a formal autism diagnosis had shorter regression path durations across conditions (β = −0.11, SE = 0.03). Variance partitioning remained similar (participants = 14.7%, images = 20.6%, residual = 64.7%).

Model 4: Combined Model

Including both Attention Problems and ASD Formal Diagnosis did not significantly improve fit relative to the attention-only model, Δ−2LL = 12.34, *p* = .217. The main effect of condition remained significant, F(3, 89.60) = 4.48, *p* = .006. Autism diagnosis was a significant predictor, F(1, 53.97) = 17.11, *p* < .001. In contrast, Attention Problems were not significant, F(1, 121.00) = 0.33, *p* = .57. Variance partitioning indicated that 14.8% of variance was attributable to participants, 20.8% to images, and 64.4% to residual error. All random effects remained significant (Wald Z > 3.7, *p* < .001).

Second Fixation Duration

Second fixation duration captures how long participants maintain their gaze during the second fixation within the area of interest. It reflects the refinement phase of visual attention, when perceptual systems integrate new input with prior expectations to update internal models of the scene.

Empty Model

A cross-classified random-intercepts model provided the best-fitting baseline structure. The full empty model (−2LL = 13,331.92) fit significantly better than the error-only model, $\chi^2(2) = 1{,}465.71$, *p* < .001. Variance partitioning indicated that 10.1% of the total variance was attributable to participants, 17.5% to image stimuli, and 72.4% to trial-level residual error, confirming meaningful clustering at both the participant and image levels.

Model 1: Condition

Including gaze condition significantly improved model fit relative to the empty model, Δ−2LL = 33.72, $\chi^2(3) = 14.64$, *p* < .001. Condition had a significant fixed effect on second fixation duration, F(3, 90.73) = 14.64, *p* < .001. Participants demonstrated the longest second fixation durations in the Delayed Participant-Directed condition when compared to the Stable Averted Condition (*p* < .001). This pattern demonstrated that eye movements toward the observer, or a shift to direct gaze, captured social attention more effectively than static gaze cues.

Model 2: Attention Problems

Including Attention Problems T-score significantly improved model fit, Δ−2LL = 9.14, $\chi^2(1) = 9.14$, *p* = .037. Attention Problems significantly predicted second fixation duration, F(1, 4,953) = 4.35, *p* = .037, with higher scores linked to shorter durations (β = −0.009, *SE* = 0.004).

Model 3: Autism Diagnosis

Adding ASD Formal Diagnosis significantly improved model fit relative to the condition-only model, Δ–2LL = 14.73, $\chi^2(1) = 14.73$, *p* < .001. The main effect of condition remained significant, F(3, 89.51) = 4.62, *p* = .005, and ASD diagnosis also significantly predicted second fixation duration, F(1, 54.20) = 18.93, *p* < .001. Individuals with a formal autism diagnosis exhibited shorter second fixation durations across conditions (β = –0.11, *SE* = 0.03). Variance partitioning remained stable (participants = 17.2 %, images = 18.0 %, residual = 64.8 %). Figure 4 depicts heat maps of fixation duration and location for one participant in the Formal Diagnosis of autism group and one non-autistic participant during one trial in the Delayed Directed Condition of the SITC task. This image illustrates differences in gaze patterns and second fixation durations between autistic and non-autistic groups.

Model 4: Combined Model

When ASD diagnosis and Attention Problems were modeled together, neither remained significant predictors (ASD: F(1, 50.04) = 0.007, *p* = .93; Attention: F(1, 50.04) = 0.36, *p* = .55). It is important to note that Attention Problems were significant when entered before Formal Diagnosis of Autism but not after, suggesting shared variance between these constructs.

Fixation Count

Fixation count represents the number of distinct fixations participants make within the area of interest. It indexes the frequency with which attention is reoriented to socially relevant cues, reflecting both attentional orienting and monitoring processes. Because fixation count is a discrete variable characterized by low mean values and moderate overdispersion ($M = 0.57$, $Var = 1.01$), a GLMM with a log link function was estimated using the *glmmTMB* package in R (Brooks et al., 2017). The model included trial-level gaze condition (Stable Averted, Stable Participant-Directed, Delayed Averted, Delayed Participant-Directed) as a fixed effect and two participant-level predictors: formal ASD diagnosis (0 = no diagnosis, 1 = formal diagnosis) and Attention Problems T-score (ASR). Random intercepts were included for participant and image, reflecting the cross-classified design in which each participant viewed multiple stimuli.

The overall model fit the data well, AIC = 3907.2, BIC = 3958.6, log-likelihood = –1944.6. The dispersion parameter ($\varphi = 9.61$) confirmed moderate overdispersion, supporting the use of the

Negative Binomial. Variance partitioning indicated that 31% of residual variance was attributable to between-image differences (*SD* = 0.95) and 21% to between-participant differences (*SD* = 0.64). A likelihood-ratio test comparing the Negative Binomial model to an equivalent Poisson GLMM favored the Negative Binomial specification, ΔAIC = 44.1.

Fixed-effects results are shown in Table 4. There was a significant main effect of condition, $\chi^2(3) = 25.46$, $p < .001$, indicating that fixation frequency differed across gaze conditions. Follow-up contrasts (estimated marginal means) revealed higher fixation counts in the Delayed Participant-Directed condition relative to the Stable-Averted baseline (b = 0.46, *SE* = 0.14, z = 3.35, *p* = .001). The Stable-Directed (b = 0.66, *p* = .07) and Delayed-Averted (b = 0.41, *p* = .26) conditions were nonsignificant. Neither a formal ASD diagnosis (b = 0.08, *p* = .68) nor Attention Problems T-score (b ≈ 0, *p* = .98) significantly predicted fixation count.

Across all conditions, participants made an average of 0.57 fixations per trial (*SD* ≈ 1.00), corresponding to an expected log-count of –1.59 for the Stable-Averted baseline. ICC estimates suggested that fixation counts varied somewhat more across stimuli than across participants, consistent with the cross-classified random structure.

Discussion

The current study examined how attention problems in daily life, adaptive social functioning outcomes, and autism characteristics relate to gaze behavior during a dynamic social perception task. Using a SITC paradigm, participants viewed crowds of faces in which one face varied in gaze direction and movement, simulating moments of eye contact. The study aimed to determine (1) whether attention problems are associated with differences in perceptual reaction time and attentional engagement when viewing social information (e.g., perceiving averted versus direct gaze), (2) whether adaptive social functioning moderates this relationship, and (3) whether models that incorporate attention problems and adaptive social functioning explain variability in social gaze behavior better than models that rely on autism characteristics alone.

General Patterns of Social Attention

Participants reliably attended to the eyes of faces within the crowd, indicating consistent engagement with socially meaningful cues. Dwell time was shorter among participants who reported more attention problems. Participants were quicker to shift their gaze away from faces in the stable averted condition compared to the delayed participant-directed condition across groups, but participants with an autism diagnosis tended to spend less time re-fixating on faces across conditions. Second fixation duration, which reflects how long participants continued attending to a face after a change in gaze direction, was negatively associated with attention problems. Participants with higher attention difficulties spent less time sustaining their gaze following a cue change, and those with an autism diagnosis also showed shorter second fixation durations. All participants also made more fixations in the delayed participant-directed condition than in the Stable Averted Condition, suggesting that dynamic gaze shifts were more closely associated with attentional engagement than static displays. Overall, these patterns indicate that attention problem outcomes and autism were associated with differences in how adults visually engaged with dynamic gaze cues in complex social scenes.

Despite the inclusion of diagnostic status and attention capabilities in daily life, a substantial portion of variability in gaze behavior remained unexplained by the current models. Variance decomposition indicated that a substantial share of the residual variance was attributable to both within-trial and between-participant sources, suggesting that gaze behavior reflects considerable heterogeneity not captured by these predictors alone. This residual variance likely reflects the influence of unmeasured factors, such as anxiety factors, situational motivation, momentary attentional fluctuations, or prior social experiences, which contribute to individual differences in how participants allocate attention during social perception. These findings reinforce the view that social gaze behavior is shaped by a complex interplay of cognitive and contextual factors.

Attention Problems and Gaze Behavior

Attention problems were associated with differences in second fixation duration, indicating that attention-related variability emerged during gaze maintenance rather than during initial orienting. This measure reflects how long participants continued attending to a face after a change in gaze direction, providing a behavioral index of sustained visual engagement. Participants with higher attention problem scores spent less time maintaining their gaze following these cue changes across conditions. The lack of consistency for fixation count, regression path duration, or dwell time suggests that early orienting and re-engagement processes were broadly consistent across individuals, while sustaining attention once engaged was more sensitive to individual differences in attentional control.

These results align with previous evidence that re-fixation on a relevant IA after looking away during visual processing assesses the maintenance of attention once it has been allocated, reflecting cognitive control and sustained engagement more than perceptual detection (Birmingham & Kingstone, 2009; Dalrymple et al., 2020). Within predictive coding and attentional regulation frameworks, this pattern may indicate that individuals with higher attention difficulties tend to disengage more quickly from stable or predictable stimuli once expectations are met (Ramamoorthy, 2020; Ristic & Capozzi, 2022).

These findings suggest that attention problems were specifically related to how long participants sustained gaze after socially meaningful changes, rather than how they initially oriented toward faces. Second fixation duration may therefore serve as a useful behavioral index of sustained attention in social-perceptual contexts, highlighting subtle individual differences in how adults manage visual engagement once a social cue has been detected.

Autism Diagnosis and Social-Perceptual Strategies

I found that outcomes of attention problems and autism may index closely related processes, with their effects becoming less differentiated when considered together. The overlapping variance appeared to reduce the strength of each predictor across all significant outcomes, consistent with findings in previous research on shared mechanisms related to executive control, cognitive flexibility, or sustained focus (Astle & Fletcher-Watson, 2020; Nigg et al., 2020).

A formal autism diagnosis was associated with faster regression trajectories and shorter second fixation durations, suggesting that autistic participants engaged with socially relevant visual information for briefer periods once attention was allocated. These differences were consistent across conditions and indicate that autistic participants spent less time sustaining gaze following a change in social cues. In contrast, measures capturing initial orienting, such as fixation count and dwell time, did not differ significantly by diagnosis, implying that the detection of social cues was similar across groups.

This pattern suggests that differences in gaze behavior among autistic participants were most evident during later phases of visual engagement, when attention was maintained or redirected, rather than during initially orienting to a cue. These results align with prior research showing that autistic adults can accurately detect and interpret gaze direction but may process social information more efficiently, relying on fewer or shorter fixations to extract meaning (Palmer et al., 2018; Stagg et al., 2022; Ramamoorthy et al., 2021). Within the context of the current study, these findings emphasize that autism-related variability in gaze behavior reflects distinct attentional patterns rather than generalized reductions in social attention.

Importantly, these findings do not necessarily imply a deficit in gaze perception. Rather, they point to a different style of visual processing. Prior work has shown that autistic individuals can accurately detect and interpret gaze direction, often doing so more efficiently by relying on fewer fixations to extract information (Palmer et al., 2018; Ramamoorthy et al., 2021). Returning to a cue more quickly and with shorter second fixation durations may reflect a perceptual strategy optimized for speed and selectivity, consistent with research on social-perceptual efficiency among autistic adults (Palmer et al., 2018; Crehan & Althoff, 2021; Stagg et al., 2022; Ramamoorthy et al., 2021).

This interpretation is further supported by the lack of interaction between autism diagnosis and gaze condition. Autistic participants did not show reduced sensitivity to direct gaze; rather, they reengaged with all gaze types in a consistently briefer manner. This contrasts with earlier SITC findings, which reported reduced attention to self-directed gaze specifically among autistic adults (Crehan & Althoff, 2015). The difference may partly be due to the larger, more diverse sample in the current study, which provides greater statistical power and greater variability in both gaze behavior and individual characteristics. With increased power, subtle within-group differences are less likely to appear as categorical effects, revealing instead that autistic adults exhibit consistent, efficient engagement patterns across contexts rather than selective disengagement from self-directed gaze.

Adaptive Functioning and Strength-Based Factors

Adaptive social functioning, operationalized through personal strengths scores, did not predict any gaze outcomes. This finding differs from my hypothesis that individuals with higher prosocial and adaptive functioning would exhibit more sustained or socially oriented gaze behavior (Dvorsky & Langberg, 2016; Masten & Obradović, 2006). Although adaptive social functioning and personal strengths differed significantly across diagnostic groups, these factors did not predict gaze behavior in the current models. The consistent pattern of lower adaptive functioning and self-reported strengths among autistic participants underscores the importance of targeting these constructs as a part of well-being measures used in autism research.

Group analyses indicated that adults with autism diagnoses and those meeting ADOS criteria reported significantly lower adaptive and personal-strengths scores than neurotypical peers. The absence of associations between diagnostic or adaptive social functioning and dwell time and fixation count may suggest that the SITC task primarily indexes early, stimulus-driven orienting rather than higher-order attentional regulation or social interpretation. These null findings support the interpretation that early perceptual detection of gaze is relatively preserved, whereas individual differences emerge later during gaze maintenance, disengagement, and reengagement. The lack of association between adaptive social functioning and SITC outcomes could suggest the task's passive, perceptual nature. The SITC paradigm is designed to isolate visual attentional responses to gaze cues rather than to capture interactive social behavior, decision-making, or real-time social competence. As such, adaptive social functioning, particularly skills related to communication, independence, and social participation, may be more relevant in contexts that require reciprocal engagement, goal-directed interaction, or social problem-solving. In the present task, gaze behavior reflects perceptual sensitivity and attentional regulation rather than the application of adaptive social skills, thereby limiting the extent to which self-reported social skill outcomes predict performance.

The passive nature of the SITC task may also have limited the opportunity for prosocial motivation to influence behavior. There appears to be a lack of studies linking adaptive social functioning to gaze behavior during interactive tasks involving joint attention or emotion recognition. The lack of association in this study suggests that adaptive strengths, while critical for social success in everyday life, may not directly shape low-level perceptual mechanisms. Instead, they may operate as compensatory or higher-order factors that emerge in active, interactive contexts rather than in passive observation of self-directed gaze.

Although this study adopts a strengths-informed and variability-focused framework, it is essential to acknowledge that autism has been robustly associated with negative social skill outcomes that meaningfully affect well-being across the lifespan. Lower adaptive social functioning has been linked to reduced quality of life, increased loneliness, and challenges in employment and independent living, underscoring that social-perceptual efficiency does not necessarily translate into positive functional outcomes. In this context, strengths and vulnerabilities should be understood as co-occurring rather than mutually exclusive. The present findings suggest that while gaze behavior may reflect efficient perceptual strategies in autistic adults, these strategies may operate alongside broader social or regulatory challenges that are not captured by passive perceptual tasks. Recognizing this distinction highlights the importance of studying how perceptual strengths interact with environmental demands, social expectations, and support structures, rather than assuming that efficient processing alone mitigates functional risk. While strengths-based perspectives are valuable for countering deficit-only narratives, an exclusively strengths-focused approach risks overlooking how differences may still contribute to functional difficulties that affect well-being. This approach allows the nuance that similar gaze patterns may support successful social engagement in some contexts while contributing to misalignment or fatigue in others.

Integrating Dimensional and Categorical Models

A central goal of the present study was to characterize variability in social gaze behavior rather than to identify clinical deficits or impairments. By comparing models using formal autism diagnoses with those including self-reported diagnoses with an ADOS, this study aims to clarify how research design choices capture distinct aspects of social cognition. Consistent with dimensional and strengths-informed approaches, gaze responses in the SITC task were treated as reflecting individual differences in perceptual style, attentional regulation, and social information processing. This framing emphasized explanation over classification, focusing on how attentional and social-perceptual mechanisms vary across individuals with different diagnostic histories and levels of adaptive social functioning. Across all dependent measures, a formal autism diagnosis provided a more stable and interpretable account of gaze behavior than ADOS classification, adaptive social functioning, and attention problems in daily life, emphasizing that autistic adults may have a distinct perceptual style, but self-report outcomes alone may not fully capture their association with social and attentional processes.

Rather than viewing categorical and dimensional models as competing explanations, the modeling approach used here separates variance attributed to the SITC image, its condition (dynamic or stable), and the participant attributes to integrate gaze-based behavioral measures with clinical characteristics and context-sensitive attentional processes. Formal diagnosis contextualizes long-term developmental patterns, whereas gaze behavior reflects current cognitive and affective mechanisms underlying the maintenance and regulation of social engagement. By embedding both within the same analytic framework, this study contributes methodologically to ongoing efforts to model social attention as a dynamic, multilevel construct. In doing so, the present study moves beyond group comparisons toward a more nuanced account of how diagnosis, attention, and perception jointly shape social engagement across individuals. This approach aligns with frameworks such as RDoC (Insel et al., 2010), which emphasize measurement strategies that bridge individual variability in cognition, emotion, and observable behavior.

The affective component of RDoC was not explored in this study. An additional consideration is the potential influence of anxiety on social attention and gaze behavior, which was also not considered in the present study. Anxiety has been shown to modulate eye contact and gaze avoidance in social contexts, particularly during situations involving perceived social evaluation or sustained mutual attention (Armstrong & Olatunji, 2012). It is therefore plausible that individual differences in anxiety could shape how participants regulate gaze during moments of participant-directed attention in the SITC task. The omission of an explicit anxiety measure limits the ability to disentangle attentional regulation from affective avoidance processes. Anxiety was not modeled here to maintain analytic parsimony and because available measures were diagnostic history and clinical assessment, which did not capture state-level anxiety during task performance. Future research should incorporate concurrent assessments of social or state anxiety to clarify how affective factors interact with attentional and perceptual mechanisms during social gaze processing.

Contextual Sensitivity to Gaze

Participants made fewer fixations on the eyes in the Stable Averted condition than in the Delayed Participant-Directed condition, indicating that they were more likely to reorient their gaze repeatedly within the area of interest when it was a gaze that turned toward them mid-trial. This cue, which signals reciprocal attention, appeared to prompt reengagement with the socially relevant eyes. Similarly, regression path duration analyses indicated longer reengagement durations in the Delayed Participant-Directed condition than within the Stable Averted condition. These patterns align with the finding that second fixation duration was longer for all participants when gaze shifted toward the participant than in the Stable Averted condition. These results suggest that a shift toward self-directed gaze was the most attention-capturing cue within the task, eliciting deeper or prolonged re-engagement compared to static gaze cues.

In addition to participant-level variability, a substantial proportion of variance in gaze behavior was attributable to image-level differences. This finding indicates that heterogeneity across stimuli must be accounted for prior to interpreting the SITC task. Differences in face size, spatial arrangement, crowd density, and visual salience likely influenced the ease with which gaze cues were detected and reengaged, contributing to variability in fixation behavior across trials. These results support the use of cross-classified analytic approaches.

Other expected condition differences, such as those between the Stable Averted and Delayed Averted conditions, were not significant in this study. This partially diverges from prior work suggesting broader differences between static and dynamic displays (e.g., Stagg et al., 2022; von Grünau & Anston, 1995). One explanation is that the present paradigm intentionally used primarily static crowd images to minimize visual noise and isolate how participants reoriented attention to the eyes when a single gaze shift occurred. Within this controlled context, the contrast between averted and participant-directed gaze served as the primary dynamic cue. Because the rest of the image remained static, these gaze shifts were perceptually salient and allowed for precise measurement of attentional refixation following an attentional shift, capturing the specificity of gaze-related engagement rather than more generalized responses to motion or social complexity.

By comparison, Stagg et al. (2022) demonstrated that when stimuli were static, emotion recognition ability did not differ between autistic and non-autistic adolescents; however, when they included dynamic, emotionally expressive video clips, differences in social attention emerged more strongly between the groups. Their work showed that emotional expressions, movement, and contextual cues collectively modulate how social cues are interpreted by autistic participants because reduced sensitivity to subtle emotional incongruities emerges in dynamic scenes. Future research incorporating video or immersive environments could build on this approach to examine how gaze modulation interacts with emotion, movement, and context to shape social perception in real-world settings.

SITC Paradigm

The SITC paradigm revealed several methodological strengths and clear constraints. The task was effective in isolating gaze-specific attentional reengagement, particularly through measures such as second fixation duration and regression path duration, which captured meaningful differences associated with attention problems and autism diagnosis. The use of tightly defined interest areas and gaze shift behavior enabled precise measurement of perceptual responses to socially salient cues while minimizing extraneous visual noise. However, the largely static and passive nature of the task limited its ability to capture higher-order interactive processes. As a result, the paradigm was better suited for characterizing perceptual and attentional mechanisms than for assessing functional social competence. These observations suggest that the SITC task is most informative when used as a component measure within a broader assessment framework rather than as a standalone index of social functioning.

The absence of associations between autism or adaptive social functioning and dwell time and fixation count suggests that these metrics primarily index early, stimulus-driven orienting rather than higher-order attentional regulation or social interpretation. In the context of the SITC task, dwell time reflects overall exposure to socially salient regions, and fixation count reflects basic sampling of visual information within the scene. The consistency of these measures across participants indicates that initial orienting to gaze cues was broadly similar regardless of diagnostic status and self-reported adaptive social functioning.

An additional consideration concerns the test–retest reliability and temporal sensitivity of the SITC task. Although the paradigm captures gaze engagement, it may be too brief and too simple a task demand to detect meaningful change over short time intervals. Because the task emphasizes rapid, stimulus-driven responses, repeated administrations may elicit similar patterns even if broader social experience or adaptive social functioning evolves. Future work should therefore explicitly evaluate the reliability of SITC metrics across sessions and examine which gaze-behavior measures are sensitive to change over time. Establishing these properties is essential before using SITC outcomes to draw conclusions about developmental trajectories or intervention-related change.

Limitations and Future Directions

A primary direction for future research is to redesign the SITC paradigm to better capture ecologically valid social interactions. While the current task was intentionally constrained to isolate attentional responses to gaze direction, future iterations could incorporate video-based stimuli, camera-mediated dyadic interactions, or immersive virtual reality environments that include facial expressions, body posture, and conversational timing. Such designs would allow us to examine how gaze allocation unfolds in reciprocal social contexts in which adaptive social functioning skills and prosocial behavior are engaged in real time. Expanding the task in this way would preserve the strengths of the SITC framework while enabling investigation of how attentional regulation interacts with higher-order social processes in more naturalistic settings. Future studies could extend this work using video stimuli or virtual reality environments that incorporate emotional expressions, body language, and speech cues.

If given the opportunity to redesign the SITC task, several modifications could increase its ecological validity while preserving its strength in isolating gaze-related attention. One promising direction would involve incorporating camera-based, two-person interactions in which participants' gaze behavior dynamically influences a social partner's responses, allowing adaptive social functioning to play a more active role in shaping attentional strategies. Alternatively, video-based or immersive virtual reality versions of the task could introduce graded social contingencies, such as emotional expressions, conversational timing, or competing social signals, while still permitting precise eye-tracking measurement. These approaches would extend the SITC framework beyond passive viewing toward interactive contexts, enabling researchers to examine how perceptual efficiency, attentional regulation, and adaptive social functioning jointly shape gaze behavior in situations that more closely approximate everyday social interaction.

Although attention and adaptive functioning were measured using validated self-report instruments, these assessments primarily reflect general tendencies rather than moment-to-moment attentional control. Self-reports capture how individuals perceive their own abilities or challenges but may not align precisely with their real-time cognitive performance during perceptual tasks. Future research could strengthen construct validity by combining self-report data with behavioral or physiological indicators of attention regulation, such as continuous performance tasks, pupillometry, or neural markers of sustained engagement. Integrating one or more of these complementary methods would help clarify the mechanisms that link attentional variability to observable patterns of social gaze behavior. Such multimodal approaches would also help differentiate between individual differences rooted in self-perception and those emerging from underlying cognitive control processes.

The cross-sectional design of the current study limits inferences about how gaze behavior and attention evolve over time. When linking gaze behavior to cognition, it remains unclear whether shorter gaze durations observed among autistic participants reflect enduring dispositions or are dependent on contextual factors. Longitudinal studies tracking gaze behavior from adolescence through adulthood could address this question by examining how gaze behaviors associated with visual attention and social context interact to shape visual engagement during development. Examining how attentional processes evolve with experience may reveal whether people refine or reorganize their strategies for processing social information. Adopting a developmental perspective is essential for distinguishing whether individuals' patterns of social attention remain consistent or change over time.

Future research should also aim to clarify how differences in gaze perception arise from individualized patterns of predictive processing. Bayesian predictive coding models conceptualize perception as an inferential process in which the brain continuously generates and updates predictions about incoming sensory input, adjusting them in proportion to the precision of the observed evidence (Friston, 2013; Pellicano & Burr, 2012). Within this framework, social gaze perception involves balancing prior expectations about where others are likely to look with new visual information, producing a prediction error signal when observed gaze deviates from expectation (Lawson et al., 2014; Van de Cruys et al., 2014). Pantelis and Kennedy (2017) found that autistic adults showed greater heterogeneity in how they weighted contextual salience cues when inferring gaze direction, with some over relying on nonsocial visual features and others entirely underweighting context. This suggests that gaze perception variability in autism may reflect distinct patterns of predictive updating rather than uniformly weaker perceptual accuracy to gaze cues.

Applying these insights to future SITC eye tracking paradigms could demonstrate how adults with varying attention profiles and adaptive functioning integrate visual and contextual information over time. A dynamic predictive coding framework could be modeled by combining trial-level eye-tracking data with Bayesian hierarchical estimation to quantify participant-specific learning parameters. Parameters, such as the precision of gaze prior and the rate of prediction-error updating, could be used to understand cognitive patterns and profiles at the computational level.

For instance, researchers could use a dynamic variant of the Stare-in-the-Crowd task where gaze direction and social context evolve gradually rather than abruptly. A Bayesian approach could estimate how participants adapt to changing gaze contingencies across trials, capturing differences in perceptual flexibility. Such a framework could distinguish adaptive prediction updating (i.e., efficient confirmation of expected stimuli) versus underweighting of prior gaze cues.

It is important to note that the analyses reported here were conducted on a preliminary subset of the KISS dataset. For future work, analyses will be run using the finalized KISS sample. Thus, the present results should be interpreted as preliminary patterns that guide, rather than finalize, conclusions about differences in social gaze in young adults.

Conclusions

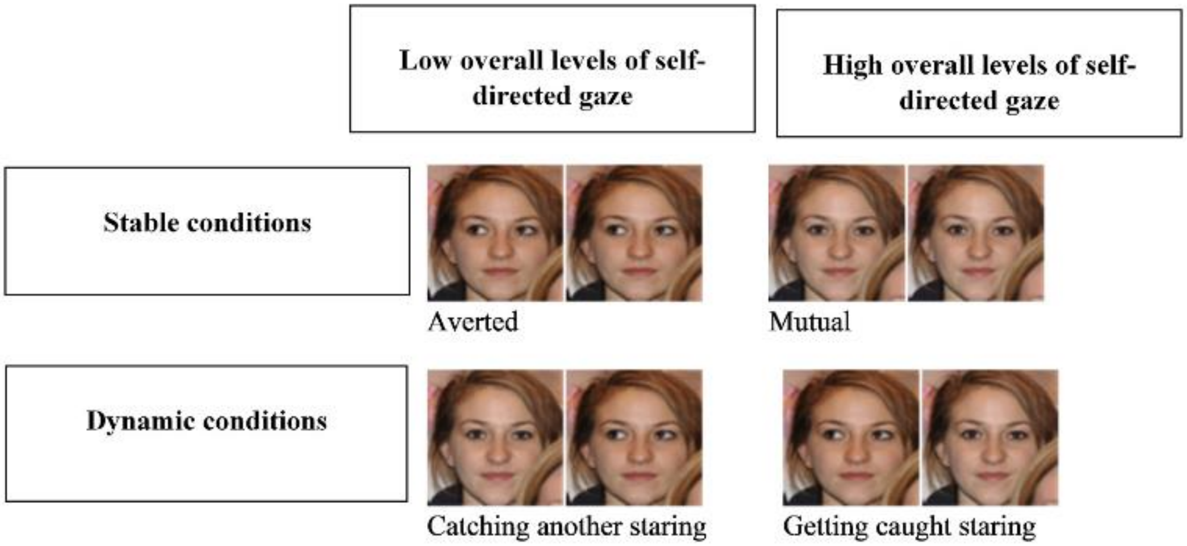
The present study examined how autism diagnosis, attention problems, and adaptive social functioning relate to social gaze behavior using an SITC eye tracking paradigm. Autism diagnosis was associated with differences in gaze behavior during social perception, with participants with autism demonstrating shorter time to return to directed gaze and briefer second fixations to the eyes across conditions. These results may reflect a distinctive pattern in this group when attending to others' gaze. Attention problems were associated specifically with shorter second fixation durations, indicating reduced maintenance of gaze following a cue change rather than general difficulties sustaining engagement. Adaptive social functioning outcomes were unrelated to gaze measures in this passive viewing context.

These findings extend prior research by demonstrating that social gaze differences in autistic adults are best conceptualized as variations in perceptual style rather than global deficits. The integration of shared attention frameworks links the SITC paradigm to the task demands of social perception. This study also demonstrates the importance of considering multiple factors, including real-time visual perception and attention, as well as attention problems in daily life and diagnostic history, when characterizing social processing in autism.

This study also extends prior SITC studies (e.g., Crehan & Althoff, 2015, 2021) and related work on attentional modulation during dynamic social perception (Ramamoorthy et al., 2021; Stagg et al., 2022) by incorporating both person-level and condition-level factors. The results support the use of cross-classified and repeated-measures models to disentangle participant-related group differences from condition-specific attentional responses. Future research should build on this framework by employing longitudinal and experimental designs that manipulate contextual and motivational cues to clarify how gaze-behavioral profiles change over time or across settings.

Figure 1.

Stare-in-the-Crowd Paradigm Conditions



Note. The SITC task consists of 40 images, with 10 images per condition across four conditions. In the Stable Averted condition (top left), all faces in the crowd consistently look away throughout the entire trial. In the Stable Participant-Directed condition (top right), one face maintains direct eye contact with the participant for the whole trial. In the Delayed Averted condition (bottom left), one face initially gazes at the participant but shifts to an averted gaze after the participant fixates on the designated IA. In the Delayed Participant-Directed condition (bottom right), all faces in the crowd initially look away. Then, one face's gaze shifts toward the participant once the participant fixates on the IA over the eyes.

Figure 2.

Example of Dynamic Image Sequence

Note. Example of group images used for the "catching another staring" or Delayed Averted condition.

Figure 3.

Example of the Location of the Interest Area in the SITC Task

Note. The oval denotes the interest area as it is programmed internally within the image (not visible to the participant. The green and purple dots show the participant's gaze fixating on the eyes.

Figure 4

Example of Heat Maps for one Autistic and one Non-Autistic participant

Non-ASD - Stable Averted

ASD - Stable Averted

Non-ASD - Getting caught staring

ASD - Getting caught staring

Note. The column shows a heat map for one autistic participant, depicting fixation activity across two trials of the same image: one in the Stable Averted condition and one in the Delayed Directed condition, intended to mimic being caught staring. The right column shows the same for a participant with a formal diagnosis of autism. Red indicates the location of the longest and most frequent fixations, and green indicates less visual attention.

Table 1

Sample Demographics

Variable	**Formal ASD Diagnosis (n = 40)**	**Self-identified ASD (n = 16)**	**Non-ASD (n = 71)**
Sex			
Male	17 (42.5%)	7 (43.8%)	43 (60.6%)
Female	23 (57.5%)	9 (56.2%)	28 (39.4%)
Gender Identity			
Cisgender	30 (75.0%)	11 (68.8%)	54 (76.1%)
Non-binary / Genderqueer	6 (15.0%)	2 (12.5%)	7 (9.9%)
Transgender / Gender Fluid	4 (10.0%)	3 (18.8%)	10 (14.1%)
Age (years)	20.48 (3.27)	20.38 (3.17)	21.13 (2.91)
Race			
Asian	3 (7.5%)	1 (6.3%)	3 (4.2%)
Black / African American	8 (20.0%)	2 (12.5%)	12 (16.9%)
White	24 (60.0%)	11 (68.8%)	41 (57.7%)
More than one race	5 (12.5%)	2 (12.5%)	15 (21.1%)
Ethnicity			
Hispanic / Latine	5 (12.5%)	2 (12.5%)	4 (5.6%)
ADHD Formal Diagnosis	12 (21.4%)	3 (18.8%)	14 (19.7%)

Note. Values represent **n* (%) * for categorical variables and *M (SD)* for continuous variables. Formal ASD Diagnosis = participants with a confirmed clinical diagnosis; Self-identified ASD = participants reporting a self-diagnosis without formal confirmation.

Table 2.

Clinical and Cognitive Measures by Autism Diagnostic Group

Variable	**ASD (n = 56)**	**Non-ASD (n = 71)**	**Group Differences**
IQ (WASI-II FSIQ2)	118.82 (12.70)	119.24 (13.11)	n.s.
Adaptive Functioning (Mean T-Score)	46.93 (8.47)	51.92 (7.66)	$p < .001$
Personal Strengths (T-Score)	46.55 (8.48)	51.54 (7.55)	$p = .008$
Attention Problems (T-Score)	59.12 (7.88)	56.41 (7.64)	n.s.

Note. Values represent *M (SD)* for continuous measures, and n.s. indicates no significance.

Table 3.

Descriptive Statistics for Continuous Predictors and Gaze-Behavior Outcomes

Variable	Type	M	SD	Min	Max	Transformation
Predictors						
Attention Problems T-Score	Level 2	59.12	7.88	40	77	None
Personal Strengths T-Score	Level 2	48.66	8.21	30	68	None
Mean Adaptive T-Score	Level 2	49.89	7.72	31	69	None
Outcomes (Eye-tracking measures)						
Dwell Time (ms)	Level 1	354.52	652.24	0	4058	log10
Fixation Count	Level 1	0.57	1.00	0	8	negative binomial link
Second Fixation Duration (ms)	Level 1	92.31	260.37	0	3374	log10
Regression Path Duration (ms)	Level 1	190.45	378.67	0	3457	log10

Table 4.

Negative Binomial Generalized Linear Mixed-Effects Model Predicting Fixation Count

Predictor	***b***	***SE***	***z***	***p***	**Exp(b)**
Intercept (Stable-Averted)	–1.59	0.30	–5.37	< .001	0.20
Stable Directed	0.66	0.36	1.82	.07	1.94
Delayed Averted	0.41	0.36	1.13	.26	1.50
Delayed Directed	0.46	0.14	3.35	.001	1.59
ASD Diagnosis (1 = yes)	0.08	0.19	0.41	.68	1.08
Attention Problems T	0.00	0.00	–0.03	.98	1.00

Table 5

Outcome Summary

Dependent Variable	**Significant Predictors**	**Condition Effect**	**Model Fit Improvement**
Dwell Time	—	—	Attention improved fit (Δ−2LL = 736, $p <$ .001)
Regression Path Duration	Autism negatively associated ($p < .001$)	Condition ($p = .006$)	Autism improved fit (Δ−2LL = 130.49, $p <$ .001)
Second Fixation Duration	Attention negatively associated ($p = .037$), Autism negatively associated ($p < .001$)	Delayed-Directed > Stable-Averted ($p <$ .001)	Attention improved fit (Δ−2LL = 9.14, $p =$ .037); Autism improved fit (Δ−2LL = 14.73, $p <$ .001)
Fixation Count	—	Delayed-Directed > Stable-Averted ($p =$ .001)	Condition only ($p <$ .001)

Appendix

ASR Questions

Adaptive Functioning Scale

I. SPOUSE OR PARTNER:

What is your marital status?	○ Never been married ○ Married but separated from spouse ○ Married, living with spouse ○ Divorced ○ Widowed ○ Other ○ I prefer not to answer/I don't know
Please describe "Other"	______________________________
At any time in the past 6 months, did you live with your spouse or with a partner?	○ No ○ Yes ○ I prefer not to answer/I don't know

II. Family

Compared with others, how well do you:

	Worse than Average	Variable or Average	Better than Average	No Contact	Not applicable/Deceased	I prefer not to answer/I don't know
Get along with your brothers?	○	○	○	○	○	○
Get along with your sisters?	○	○	○	○	○	○
Get along with your mother?	○	○	○	○	○	○
Get along with your father?	○	○	○	○	○	○
Get along with your biological or adopted children?	○	○	○	○	○	○

Please describe your educational experience during the past 6 months:

	Not True	Somewhat or Sometimes True	Very True or Often True	I prefer not to answer/I don't know
I get along well with other students	○	○	○	○
I achieve what I am capable of	○	○	○	○
I have trouble finishing assignments	○	○	○	○
I am satisfied with my educational situation	○	○	○	○
I do things that may cause me to fail	○	○	○	○

IV. Education

At any time in the past 6 months, did you attend school, college, or any other educational or training program?	○ No ○ Yes ○ I prefer not to answer/I don't know
What kind of school or program?	______________________________
What degree or diploma are you seeking?	______________________________
When do you expect to receive your degree or diploma?	______________________________

Oldest child	○	○	○	○	○	○
2nd oldest child	○	○	○	○	○	○
3rd oldest child	○	○	○	○	○	○
Other children	○	○	○	○	○	○
Get along with your stepchildren?	○	○	○	○	○	○

III. JOB

At any time in the past 6 months, did you have any paid jobs (including self-employment and military service)?	○ No ○ Yes ○ I prefer not to answer/I don't know

Please describe your work experience during the past 6 months:

	Not True	Somewhat or Sometimes True	Very True or Often True	I prefer not to answer/I don't know
I work well with others	○	○	○	○
I have trouble getting along with bosses	○	○	○	○
I do my work well	○	○	○	○
I have trouble finishing my work	○	○	○	○
I am satisfied with my work situation	○	○	○	○
I do things that may cause me to lose my job	○	○	○	○
I stay away from my job even when I'm not sick or not on vacation	○	○	○	○

IV. Education

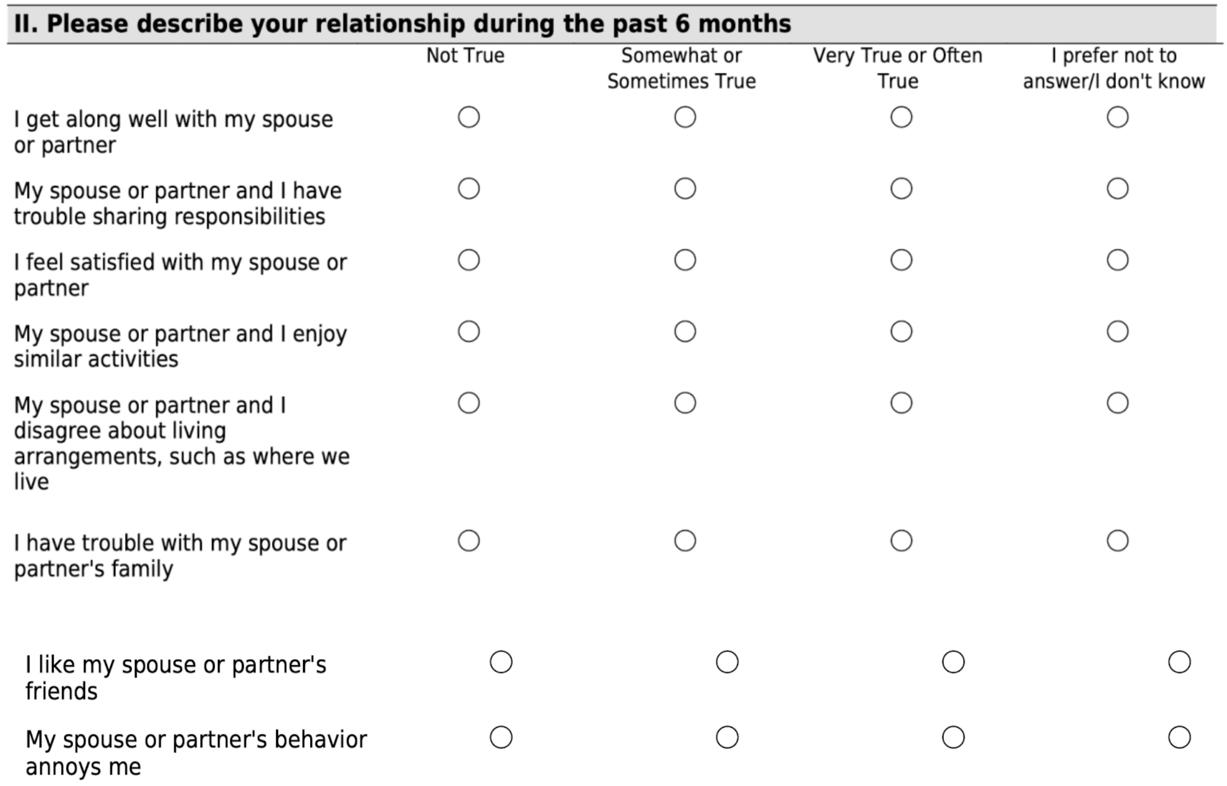
At any time in the past 6 months, did you attend school, college, or any other educational or training program?	○ No ○ Yes ○ I prefer not to answer/I don't know
What kind of school or program?	______________________________
What degree or diploma are you seeking?	______________________________
When do you expect to receive your degree or diploma?	______________________________

Please describe your educational experience during the past 6 months:

	Not True	Somewhat or Sometimes True	Very True or Often True	I prefer not to answer/I don't know
I get along well with other students	○	○	○	○
I achieve what I am capable of	○	○	○	○
I have trouble finishing assignments	○	○	○	○
I am satisfied with my educational situation	○	○	○	○
I do things that may cause me to fail	○	○	○	○

IX. FRIENDS

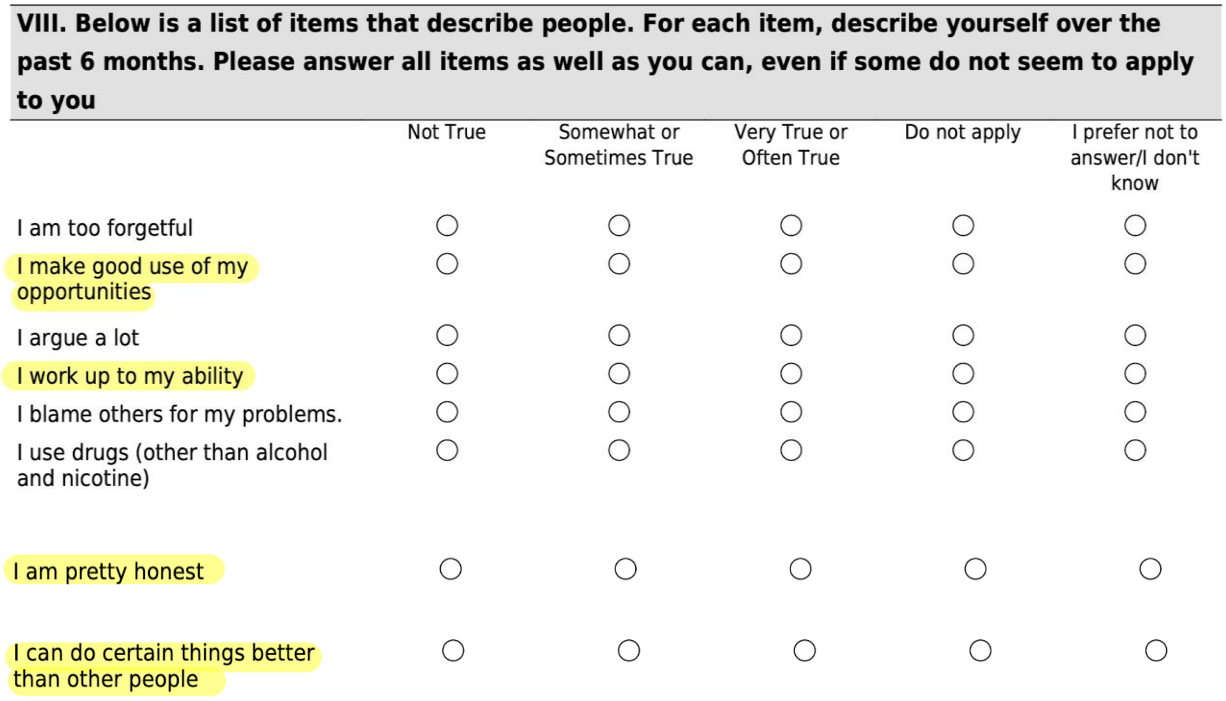
About how many close friends do you have? (Do not include family members.)	○ None ○ 1 ○ 2 or 3 ○ 4 or more ○ I prefer not to answer/I don't know
About how many times a month do you have contact with any of your close friends? (Include in-person contacts, phone, letters, e-mail.)	○ Less than 1 ○ 1 or 2 ○ 2 or 3 ○ 5 or more ○ I prefer not to answer/I don't know
About how many times a month do any friends or family visit you?	○ Less than 1 ○ 1 or 2 ○ 2 or 3 ○ 5 or more ○ I prefer not to answer/I don't know
How well do you get along with your close friends?	○ Not as well as I'd like ○ Average ○ Above average ○ Far above average ○ I prefer not to answer/I don't know



II. Please describe your relationship during the past 6 months

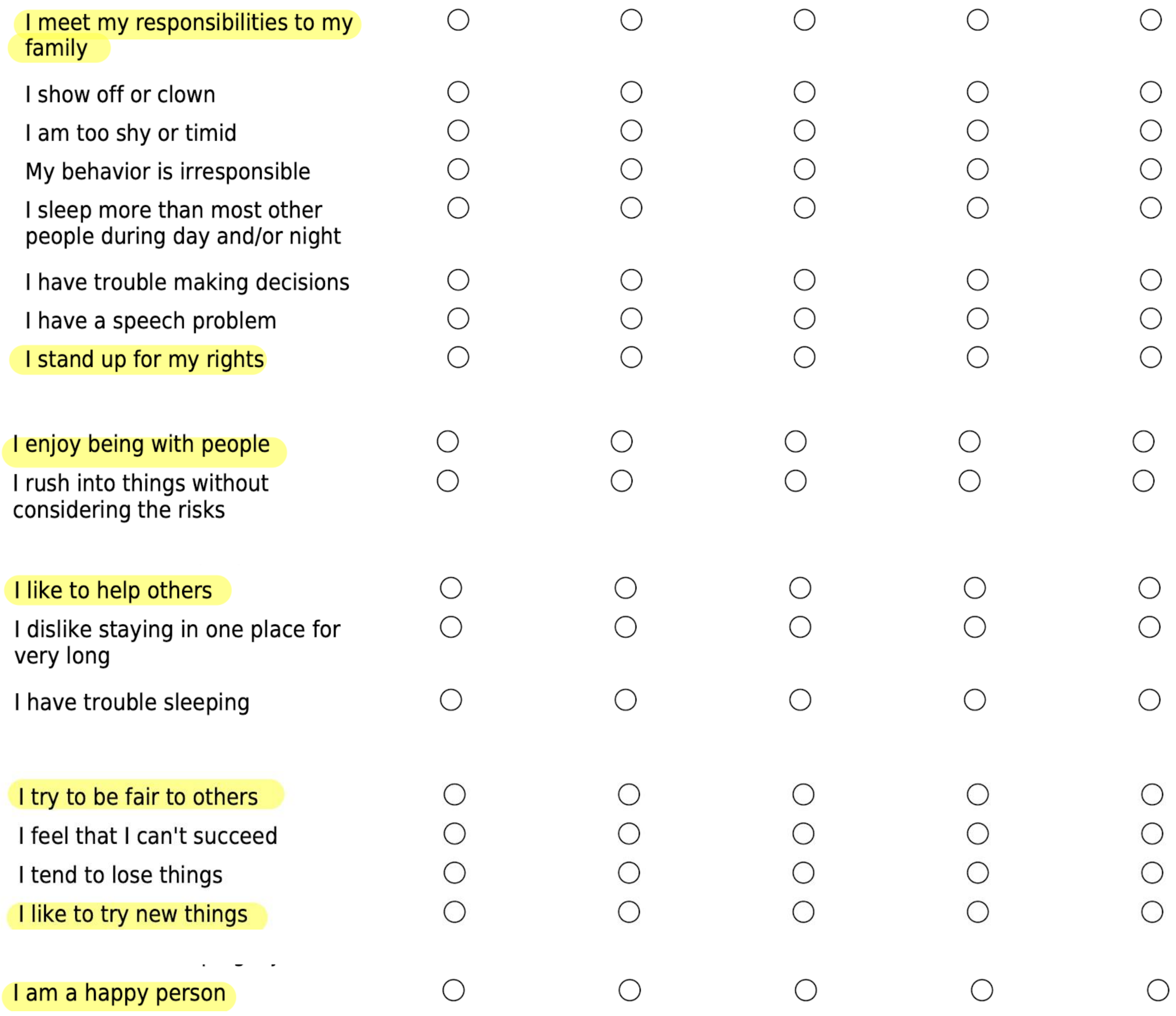
	Not True	Somewhat or Sometimes True	Very True or Often True	I prefer not to answer/I don't know
I get along well with my spouse or partner	○	○	○	○
My spouse or partner and I have trouble sharing responsibilities	○	○	○	○
I feel satisfied with my spouse or partner	○	○	○	○
My spouse or partner and I enjoy similar activities	○	○	○	○
My spouse or partner and I disagree about living arrangements, such as where we live	○	○	○	○
I have trouble with my spouse or partner's family	○	○	○	○
I like my spouse or partner's friends	○	○	○	○
My spouse or partner's behavior annoys me	○	○	○	○

Personal Strengths Scale



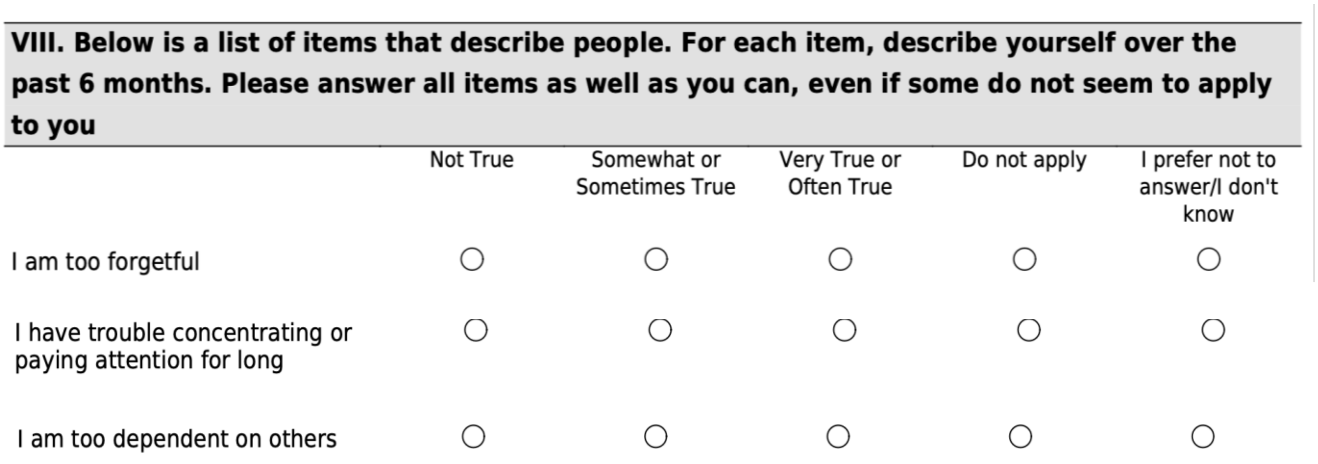
VIII. Below is a list of items that describe people. For each item, describe yourself over the past 6 months. Please answer all items as well as you can, even if some do not seem to apply to you

	Not True	Somewhat or Sometimes True	Very True or Often True	Do not apply	I prefer not to answer/I don't know
I am too forgetful	○	○	○	○	○
I make good use of my opportunities	○	○	○	○	○
I argue a lot	○	○	○	○	○
I work up to my ability	○	○	○	○	○
I blame others for my problems.	○	○	○	○	○
I use drugs (other than alcohol and nicotine)	○	○	○	○	○
I am pretty honest	○	○	○	○	○
I can do certain things better than other people	○	○	○	○	○



I meet my responsibilities to my family	○	○	○	○	○
I show off or clown	○	○	○	○	○
I am too shy or timid	○	○	○	○	○
My behavior is irresponsible	○	○	○	○	○
I sleep more than most other people during day and/or night	○	○	○	○	○
I have trouble making decisions	○	○	○	○	○
I have a speech problem	○	○	○	○	○
I stand up for my rights	○	○	○	○	○
I enjoy being with people	○	○	○	○	○
I rush into things without considering the risks	○	○	○	○	○
I like to help others	○	○	○	○	○
I dislike staying in one place for very long	○	○	○	○	○
I have trouble sleeping	○	○	○	○	○
I try to be fair to others	○	○	○	○	○
I feel that I can't succeed	○	○	○	○	○
I tend to lose things	○	○	○	○	○
I like to try new things	○	○	○	○	○
I am a happy person	○	○	○	○	○

Attention Problems



VIII. Below is a list of items that describe people. For each item, describe yourself over the past 6 months. Please answer all items as well as you can, even if some do not seem to apply to you

	Not True	Somewhat or Sometimes True	Very True or Often True	Do not apply	I prefer not to answer/I don't know
I am too forgetful	○	○	○	○	○
I have trouble concentrating or paying attention for long	○	○	○	○	○
I am too dependent on others	○	○	○	○	○

I daydream a lot	○	○	○	○	○
I have trouble planning for the future	○	○	○	○	○
I fail to finish things I should do	○	○	○	○	know ○
My work performance is poor	○	○	○	○	○
I have trouble setting priorities	○	○	○	○	○
I have trouble making decisions	○	○	○	○	○
I stay away from my job even when I'm not sick or not on vacation	○	○	○	○	○
I don't have much energy	○	○	○	○	○
People think I am disorganized	○	○	○	○	○
I tend to lose things	○	○	○	○	○
I am not good at details	○	○	○	○	○
I tend to be late for	○	○	○	○	○

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