Parental Broad Autism Phenotype Traits and Their Influence on Early Social Interaction and Attention

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Abstract

Parental mental health subclinical features, such as stress, anxiety, and depression, have been reported to significantly influence the dynamics of parent-infant interaction, which sets the stage for early attention, learning, and social communication development. However, less is known about the influence of cognitive and social features, such as those related to broad autism phenotype (BAP) traits, despite their documented impact on attention control and sensory processing. The present study examines how parental BAP traits may relate to parent-infant interaction by focusing on their behaviors, using head-mounted eye-tracking to provide objective measures. Results indicated that BAP traits were related to rates of parent sustained attention and object handling but did not predict infants' sustained attention during the interaction. The findings of variability in parental play behaviors based on BAP traits raise important questions regarding the direct impact of parental characteristics on early social interaction, infants' potential adaptations to their learning environments, and the significance of BAP traits in infant development.

Keywords: head-mounted eye-tracking, broad autism phenotype, parent-infant interaction, sustained attention, object handling

Introduction

Parental behaviors play a critical role in shaping early parent-infant interactions, particularly in relation to engagement and coordination. However, while research has well-documented the effect of parental emotional and affective behaviors, such as responsiveness and regulation, we know less about their attention-related behaviors, despite the critical role of attention in establishing advanced social-communication behaviors with infants. Parental looking behaviors, such as sustained attention to an object, lay a critical foundation for infants' learning by supporting the alignment of attention in dyadic interactions. In tandem with gaze, parents often use physical actions—such as object handling—to provide multimodal cues that further guide and scaffold their infant's attention. The present study explored the relationship between broad autism phenotype (BAP) traits and interactive behaviors (sustained attention and object manipulation) in a parent-infant object play context.

Parental Characteristics

Individual parental mental health subclinical features, such as stress, anxiety, and depression, have been well-documented to influence parent-child interactive engagement, including parental sensitivity, emotional availability, attention, and responsiveness (Feng et al., 2007; Lee et al., 2013; Lovejoy, 1991; Rao et al., 2021). Affective challenges can disrupt parents' ability to sustain meaningful interactions, thereby influencing the quality and frequency of shared moments. Indeed, parental affect has been associated with infant affect as early as 6 months old (Forbes et al., 2004). These early exchanges lay the groundwork for mutual attentional and emotional regulation and set the stage for later social-communication milestones. Other parental backgrounds that have seen considerable influence on infant development include socioeconomic status, gender, and culture (Gago-Galvagno & Elgier, 2020; Laflamme, 2003; Rabain-Jamin, 1991; Reilly et al., 2021). Socioeconomic disparities, for instance, may shape access to resources that support parental engagement, while gender and cultural norms can mediate the expression of parenting behaviors and expectations surrounding parent-child interaction (Hill & Tyson, 2008; Ho et al., 2008; Roubinov & Boyce, 2017; Weisleder et al., 2016).

Recently, researchers have focused on traits associated with the broad autism phenotype (BAP). These traits, including subtle differences in social communication, rigid thinking, and heightened attention to detail, are commonly observed in relatives of autistic individuals but can also be found in the general population (De Groot & Van Strien, 2017; Hurley et al., 2007; O. Landry & Chouinard, 2016; Sasson, Lam, Childress, et al., 2013). Understanding the role of BAP traits in parenting offers a unique lens for examining subtle variations in parent-infant interaction that may otherwise go unnoticed. This line of inquiry is particularly relevant given the growing emphasis on neurodiversity and its implications for family dynamics (DeLucia et al., 2022; Sasson, Lam, Parlier, et al., 2013). Studies have linked BAP traits to parenting behaviors, such as affect and emotion regulation (Condy et al., 2019; DeLucia et al., 2022). One study of mother-child interaction found that maternal aloofness was negatively correlated with verbal responsiveness to their children (Flippin & Watson, 2018). Parental BAP traits have also been associated with children's development, including their language, engagement, and social behaviors (Flippin & Watson, 2018; Maxwell et al., 2013). While this previous

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research has captured how parental BAP traits influence parent-child interactions, much of this work has primarily focused on emotional and affective behaviors. As a result, the role of BAP traits in other interactive domains, such as visual attention and object manipulation, remains underexplored.

Parent Scaffolding

Early parental social scaffolding, in which children's learning occurs through the tailored support of parents, has long been shown to support children's development in domains such as cognition and language (Tomasello & Farrar, 1986). Through scaffolding, parents can provide timely support to help children build the foundation for their understanding of the world, encouraging independence while ensuring the child feels secure and accepted (Bornstein et al., 2008; S. H. Landry et al., 2006). One of the earliest contexts where parent scaffolding emerges for infants is through parent-infant play, which has been coined an "early training ground" for children's learning experiences. Here, parents have been documented to use multimodal techniques, including language, gesture use, physical contact, and synchrony, to increase their infants' engagement and subsequent learning opportunities (Cherney & London, 2006; Clackson et al., 2019; Neale & Whitebread, 2019; Tomalski et al., 2022).

An increasing line of research has focused on parental visual attention, given its critical role in setting up enriched opportunities for infants to develop their own perceptual experiences (Sun & Yoshida, 2022). Head-mounted eye-tracking has provided novel insights into how parents coordinate their attention behaviors with their infant during scaffolding activities by capturing their moment-to-moment shifts in gaze and attention alignment. This methodology offers a dynamic perspective on how parents guide their infants' focus toward relevant stimuli. Among the attention behaviors most commonly studied is sustained attention (SA), which involves focusing on a shared activity or object over time. SA plays a key role in enabling joint engagement and supports the development of advanced social-communication behaviors (Richards, 1985; Richards & Casey, 1992; Ruff et al., 1990; Ruff & Lawson, 1990; Yu & Smith, 2016). Previous studies have documented that parent SA can guide their infant to look at the same object (Gredebäck et al., 2010; Suarez-Rivera et al., 2019; Yu & Smith, 2017b, 2017a) and that SA is often accompanied by other scaffolding behaviors, including object handling, which serves as an additional visual cue to draw an infant's gaze to a target of interest (Deák et al., 2018; Suarez-Rivera et al., 2019; Sun & Yoshida, 2022). For example, simultaneous object naming and object handling have been shown to predict infants' attention and vocabulary outcomes (Abney et al., 2020; Sun et al., 2022). When attention is accompanied by object handling, toddlers pay more attention to the object when named (Schroer et al., 2024). These findings suggest that parental attention and object handling can be used as multimodal referential inputs for shaping infant attention, and as such, should be considered together when examining how parents influence early learning opportunities.

Moreover, we know that parental background can impact attention and object-handling behaviors. For example, parental socioeconomic status has been linked to higher-quality interactions during joint attention (Koşkulu et al., 2021), while parental depressive symptoms have been linked to attention and object exploration (Henderson, 1981; Moszkowski et al., 2009). Despite these established associations and the importance of parental attention and object handling in shaping infants' visual experiences, the potential influence of BAP traits within parent-interactive contexts remains largely unexplored compared to other affective and regulatory behaviors. Given that BAP traits are often linked to differences in attentional focus and sensory processing in adults (Calton, 2022; Cardon et al., 2023; De Groot & Van Strien, 2017; McDonald, 2021; Yadon & Vonarx, 2024), these traits could likely influence how parents engage with their infants during shared activities. Such differences may manifest not only in where parents look but also in how they use looking behaviors in tandem with physical actions like object handling, shaping their infant's attentional engagement. This, in turn, may be highly relevant to early parent-mediated interventions that target such behaviors. This type of intervention offered to families with infants has been a large focus in clinical fields with promising results, particularly in the context of neurodevelopmental conditions related to social development (Pierucci, 2016; Tanner & Dounavi, 2020).

Hypotheses

The present study used head-mounted eye-tracking to observe parent-infant object play and investigate the impact of BAP traits on parent-infant interactive behaviors. The hypotheses are: (1) lower BAP traits will be associated with more parental SA, given previous evidence suggesting individuals with lower BAP traits may find it easier to engage in socially-relevant attention (Swanson et al., 2013; Swanson & Siller, 2014); (2) higher BAP traits will be associated with more object handling, potentially reflecting tendencies of individuals with higher BAP traits to be less flexible and a preference for routine and structure (Dawson et al., 2007; Wainer et al., 2011); and (3) lower BAP traits will be associated with more infant SA, as these parents may engage in interaction styles that more readily promote social reciprocity (Sasson, Nowlin, & Pinkham, 2013), which is likely to create a downstream effect on their infants' behaviors.

Methods

Participants

36 parent-infant dyads (19 male infants, 17 female infants, M = 9.38 months, SD = 3.11 months) participated in the present study. Infants met the following criteria to participate: full-term birth (i.e., 38 weeks or weighed >2.41

kg at birth), no documented hearing or visual impairments, and no documented intellectual, cognitive, or developmental disorders or disabilities. An additional 4 dyads were excluded for infant fussiness or equipment failure. All parents provided informed consent before the study visit and received a gift card, a local museum pass, an infant toy, and an infant T-shirt after participating.

Procedure

Parents and infants wore a Positive Science LLC head-mounted eye-tracking device (Figure 1), which consists of a head-mounted color camera that captures a view of an individual's scene and a supplementary eye camera that records an individual's pupil movements and corneal reflection (Franchak et al., 2011). Each dyad completed a six-minute parent-infant play session with six unique toys. Parents were instructed to play with their infants as naturally as possible. A nine-point calibration procedure was used multiple times immediately before and after for gaze calibration purposes. A minimum inter-correlation of 0.9 was required between the scene camera and eye camera for inclusion in the current data set; this is obtained through the Yarbus software program, which estimates an individual's eye gaze location on each frame of their scene camera video (e.g., Franchak et al., 2011). Both child and parent eye-tracking videos were synchronized with two additional views of the play session (from a wall-mounted camera and a ceiling-mounted camera) and an audio recording before being rendered at 30 frames per second using the Adobe Premiere software program. Each visit took approximately 45 minutes.

Figure 1: Egocentric viewing and gaze data were recorded using head-mounted eye trackers.

Parent participants also completed the Broad Autism Phenotype Questionnaire (BAPQ) (Hurley et al., 2007), which consists of a total score and three subscale scores for characteristics associated with the primary diagnostic domains of autism: 1) aloofness, 2) rigidity, and 3) pragmatic language. The questionnaire consists of 36 items, each rated on a six-point Likert scale (ranging from "very rarely" to "very often"). The BAPQ is suitable for assessing traits in individuals without an autism diagnosis, with higher scores indicating more prevalent BAP characteristics, and takes approximately 5 to 10 minutes to complete. The average total BAP score was 2.51 (SD = 0.59). The average aloofness score was 2.47 (SD = 0.82). The average rigidity score was 2.46 (SD = 0.71). The average pragmatic language score was 2.62 (SD = 0.65).

Behavioral Annotation

Each dyad's play-session video was imported into the Datavyu software program (Datavyu Team, 2014) for manual frame-by-frame annotation of the play session by trained research assistants. Infant and parent eye gaze locations were annotated for attention to four regions of interest: (1) face, (2) toy objects, (3) parent's hands, and (4) infant's hands. These regions of interest were chosen as they are the most common targets captured in person-centered viewing and have been used in previous head-mounted eye-tracking studies involving parent-infant play (Perkovich & Yoshida, 2024; Yu & Smith, 2013). From this annotation, we calculated the frequency per minute and duration per minute of the infant's and parent's SA moments (moments when the infant or parent looked at a region of interest for at least 2000 milliseconds) (Sun et al., 2023; Sun & Yoshida, 2024).

Additionally, given the importance of parental object handling in generating socially coordinated attention moments for infants (Burling & Yoshida, 2019; Deák et al., 2014, 2018; Yu & Smith, 2013, 2017a), we manually coded each time the parent touched one of the six toy objects with their left or right hand. From this annotation, we calculated the frequency per minute and duration per minute of unique parent object-handling instances.

Results

Parent Sustained Attention (SA)

Simple linear regression models were conducted to examine the relationship between the four BAPQ scores and parent SA behaviors. The overall BAPQ score was negatively associated with both SA frequency (p = .02) and duration (p = .01); that is, parents with lower BAP traits had more frequent and longer SA experiences than parents with higher BAP traits.

Similarly, the aloofness subscale was negatively associated with both SA frequency (p = .03) and duration (p = .02); that is, parents who were less aloof had more frequent and longer SA experiences than parents who were more aloof.

Table 1: Relationship Between BAPQ Measurements and Parent SA Behaviors

	β	R^2	*p*
Broad Autism Phenotype (BAP)			
SA Frequency	-1.90	0.16	**0.02**
SA Duration	-7.18	0.17	**0.01**
Aloofness			
SA Frequency	-1.25	0.14	**0.03**
SA Duration	-4.80	0.15	**0.02**
Rigidity			
SA Frequency	-1.31	0.09	0.07
SA Duration	-5.07	0.11	0.05
Pragmatic Language			
SA Frequency	-0.82	0.04	0.28
SA Duration	-3.06	0.04	0.27

Parent Object Handling

Simple linear regression models were conducted to examine the relationship between the four BAPQ scores and parent object-handling behaviors. The overall BAPQ score was positively associated with both object handling frequency ($p < .01$) and duration ($p < .01$); that is, parents with higher BAP traits handled objects more frequently and longer than parents with lower BAP traits.

Similarly, the rigidity subscale was positively associated with both object handling frequency ($p < .01$) and duration ($p < .01$); that is, more rigid parents handled objects more frequently and longer than less rigid parents.

The pragmatic language score was also positively associated with object handling duration ($p = .02$); that is, parents who use more pragmatic language handled objects longer than parents who use less pragmatic language.

Table 2: Relationship Between BAPQ Measurements and Parent Object Handling Behaviors

	β	R^2	*p*
Broad Autism Phenotype (BAP)			
Handling Frequency	12.29	0.36	**< 0.01**
Handling Duration	11.14	0.31	**< 0.01**
Aloofness			
Handling Frequency	4.96	0.10	0.10
Handling Duration	5.01	0.11	0.09
Rigidity			
Handling Frequency	14.40	0.53	**< 0.01**
Handling Duration	9.58	0.25	**< 0.01**
Pragmatic Language			
Handling Frequency	4.31	0.08	0.17
Handling Duration	6.80	0.21	**0.02**

Infant Sustained Attention (SA)

Simple linear regression models were conducted to examine the relationship between the four BAPQ scores and infant SA behaviors. There was no significant relationship between any BAPQ score and the frequency and duration of infant SA ($p \leq .05$).

Table 3: Relationship Between BAPQ Measurements and Infant SA Behaviors

	β	R^2	*p*
Broad Autism Phenotype (BAP)			
SA Frequency	0.43	0.86	0.36
SA Duration	1.78	0.05	0.20
Aloofness			
SA Frequency	0.20	< 0.01	0.96
SA Duration	0.36	0.01	0.73
Rigidity			
SA Frequency	0.70	0.08	0.09
SA Duration	2.37	0.11	0.05
Pragmatic Language			
SA Frequency	0.26	0.01	0.58
SA Duration	1.09	0.02	0.41

Discussion

The present study explored the relationship between parental BAP traits and parent-infant interaction behaviors, specifically SA and object handling, during a naturalistic play session. Our findings offer valuable insights into how subtle parental traits influence parenting behaviors and potentially shape early social-communication dynamics. However, we also observed notable gaps in how BAP traits relate to infant behaviors. In the following sections, we discuss the significance of these findings for early developmental interventions, as well as the limitations of the study and future research directions.

BAP Feature – Parent Behaviors

A key finding of our study was the significant associations between BAP traits and parent behaviors. Notably, lower BAP traits were associated with increased SA during the play interaction. Lower BAP traits, characterized by greater social attunement and adaptability, may facilitate SA by enabling parents to sustain their focus even in dynamic or unpredictable interactions (Albantakis et al., 2020; Jobe & Williams White, 2007; Novacek et al., 2016). This may be especially true for interactions in a laboratory environment that are inherently novel to both the parent and the infant, thereby introducing additional challenges to the interaction. This is particularly evident by the findings that lower aloof traits were predictive of increased SA. Parents who are less aloof are likely to show a greater intrinsic interest in social interactions, actively seeking out and responding to opportunities to engage and maintain their focus with their infant. This enhanced sensitivity to their infant's cues may allow them to better navigate the complexities of the interaction.

Interestingly, we also found that lower BAP traits were associated with a reduced frequency of object handling by the parent. This is particularly noteworthy, given the well-established role of object handling in engaging infants and promoting cognitive development, particularly in the context of facilitating attention to objects, predicting vocabulary growth, and mapping words to objects (Abney et al., 2020; Burling & Yoshida, 2019, 2019; Schroer et al., 2024). This result may reflect a subtle difference in play

styles. For example, parents with higher BAP traits - particularly rigidity - may gravitate towards more structured forms of play, where they adopt a guiding or leading role, as seen in their greater use of objects. This emphasis on object handling aligns with traits associated with the BAP, such as a focus on detail, routine, and systematic thinking. In contrast, parents with lower BAP traits may favor more interactive approaches that rely less on object manipulation, such as eye contact, gestures, and vocalizations. This possible distinction warrants further measurement of diverse parent behaviors to fully understand the influence of BAP traits on the broader strategies parents use to interact with their infants.

Infant Attention

In contrast to our parent results, we were surprised to find no significant negative relationship between parental BAP traits and infant SA. One possible explanation for this finding is that while BAP traits may influence the dynamics of parent-infant interactions in the long term, they may not directly influence infant attention within such a short interaction, especially in free play. While traits like aloofness or rigidity might influence social coordination behaviors, such as those involved in establishing and maintaining joint attention, SA may be moderated by infants' adaptability to the social input available in their environment. Thus, even if a parent's BAP traits influence certain social aspects of their interactions, this may not result in measurable differences in how often infants engage in SA. This is because infants may actively shape their own input to optimize their learning (Burling & Yoshida, 2019), thereby reducing the direct impact of these parental traits. This highlights the importance of further understanding how infants' attention is organized in relation to parental BAP traits and other behaviors. It also raises the question of whether factors such as infants' own learning about their environment play a more significant role in shaping self-directed attention behaviors, such as SA. This stands in contrast to more socially coordinated attention behaviors, such as joint attention, where active participation of a social partner (e.g., a parent) supports the infant's focus toward a shared target (Deák et al., 2018; Suarez-Rivera et al., 2019; Yu & Smith, 2013, 2017a). These behaviors are highly dependent on the parents' ability to engage socially and respond sensitively to infant cues, which could be influenced by traits associated with the BAP. Given that joint attention is foundational for language learning and social development (Mundy & Newell, 2007; Tomasello, 1995) and has often been linked to developmental conditions, such as autism (Frith et al., 2003; Loveland & Landry, 1986), it represents an important area for future research examining how parental traits could shape early trajectories of social engagement.

Some important considerations should be highlighted. First, while our sample size is relatively small, it still offers valuable insights into the research questions posed. Future studies with larger and more diverse samples could provide opportunities to explore additional factors, such as socioeconomic background and parent gender, which have been found to influence interaction behaviors (Çakır, 2016; Koşkulu et al., 2021; Kruper & Užgiris, 1987; Raver & Leadbeater, 1995; Saxon & Reilly, 1999; Tauber, 1979). Second, the BAPQ provides a useful tool for assessing BAP traits in adults, and while it relies on self-report, it still aligns with the goals of the study to capture the broad range of traits in the context of parenting. To enhance our understanding, future research could complement the BAPQ with additional tools, such as observational assessments (e.g., the Autism Diagnostic Observation Schedule, Second Edition [ADOS-2]) or interviews (e.g., the Autism Diagnostic Interview, Revised [ADI-R]), which would provide a more rounded view of how BAP traits impact parenting styles. Finally, as we've seen the effects of BAP traits on interaction behaviors, the next step is to explore the underlying mechanisms. For example, sensory processing differences associated with BAP traits could play a role in shaping parent-child interactions. These differences are well-documented (Calton, 2022; Cardon et al., 2023; De Groot & Van Strien, 2017; McDonald, 2021; Yadon & Vonarx, 2024) and may affect how parents engage with their infants, particularly in tactile interactions and responses to environmental stimuli.

Nonetheless, the present study, which focused on naturally occurring play behaviors, revealed the first evidence of BAP traits influencing parental attention and object-handling behaviors. This underscores the early impact of parental characteristics in shaping the multimodal cues available to infants within their early learning environment. The present study invites further research into the developmental significance of these parental traits in the early years of life when early learning and development emerge through social communication.

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