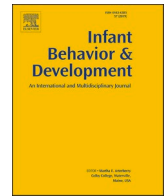




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## Investigating parental scaffolding and visual experiences in toddlers with autism and high familial likelihood for later autism diagnosis: A head-mounted eye-tracker study

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### ABSTRACT

Parents of autistic children often exhibit distinct interaction styles—such as increased gesturing and sustained focus on their child’s face—compared to parents of neurotypical children, yet the mechanisms driving these behaviors remain unclear. This study examined how parental social scaffolding behaviors influence attention in toddlers at elevated likelihood of autism (i.e., younger siblings of autistic children) and their neurotypical peers. Thirty-eight toddlers (19 per group), matched on age and sex, participated in a semi-naturalistic parent-child play session while wearing head-mounted eye-trackers. Despite no group differences in toddlers’ sustained or joint attention (SA, JA), parents showed distinct interaction patterns: parents of elevated-likelihood toddlers focused more objects, while neurotypical-group parents engaged in more object naming and face-directed attention. Across groups, parental object-looking predicted toddler JA, and object-handling predicted SA. However, the link between object-handling and JA only emerged in neurotypical toddlers, suggesting group-specific differences in how parental cues are integrated. These findings suggest that toddlers at elevated likelihood for autism show comparable attentional behaviors but receive qualitatively different social input. Parents may adjust their scaffolding strategies in response to subtle developmental cues before formal diagnosis. This study highlights the importance of considering developmental context in early social scaffolding and contributes to understanding how parental input shapes attention in diverse populations.

### 1. Introduction

Early parental social scaffolding—which refers to the individualized support that guides a child’s attention and learning—plays a crucial role in early development (Tomasello & Farrar, 1986). These early social interactions offer an essential “training ground” for shaping children’s attention and learning (Yu & Smith, 2013). Studies using head-mounted eye tracking have documented that parental behaviors, such as object naming and handling, support naturally occurring sustained attention (SA)—extended visual engagement with a target—and predict vocabulary growth (Abney et al., 2020; Sun et al., 2022). Similarly, when joint attention (JA)—shared attention toward a common target—is accompanied by both object handling and object naming, toddlers show longer looking

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0163-6383/© 2025 Elsevier Inc. All rights are reserved, including those for text and data mining, AI training, and similar technologies.

toward the object (Schroer et al., 2024).

Together, these studies highlight that micro-level scaffolding supports SA and JA, both of which are predictive of later language, cognitive, and social development (Anobile et al., 2013; Carpenter et al., 1998; Johansson et al., 2015; Mundy, 2018; Pereira et al., 2014; Tomasello, 1995; Yu et al., 2019) and underscore the importance of coordinated multimodal input in shaping early attention experiences. Accordingly, the working conjecture is that parental social scaffolding behaviors support the structure of children's visual experiences, thereby building their perceptual foundations and contributing to subsequent language learning and development through social coordination. While this constitutes an exciting potential mechanism that may be relevant to a wide variety of educational settings and intervention-related frameworks for young children with diverse learning needs, a large body of our evidence comes from studies of neurotypical children and their parents. The present study extends prior work by examining toddlers with a family history of autism (FH+), a population with known differences in attention and social communication. Specifically, we focus on how moment-to-moment SA and JA experiences relate to parental scaffolding during naturalistic object play.

### 1.1. Reassessing group differences in SA and JA: the role of interactive contexts

Recent research has examined attention in neurodivergent populations as a potential behavioral biomarker, especially in the context of autism (Boraston & Blakemore, 2007; Bradshaw et al., 2019; Falck-Ytter et al., 2013; Murias et al., 2018; Pierce et al., 2019). Autism is characterized by social communication difficulties, including atypical gaze and gesture use (Dawson et al., 2004; Jellema et al., 2009). In screen-based tasks, children with autism and FH+ toddlers typically show fewer instances of SA and JA compared to their neurotypical peers—patterns that are predictive of later communication outcomes (Franchini et al., 2019; Liu et al., 2021; Navab et al., 2011; Nyström et al., 2019; Presmanes et al., 2007). While these measures offer valuable insights into visual attention under standardized conditions, they may underrepresent how attention is shaped through dynamic, social, and interactive experiences. Naturalistic approaches aim to address this gap by situating attention in everyday social contexts. However, many of these methods rely on observer-coded behavioral data—whether from third-person video or live annotation—which can introduce limitations in measurement precision and temporal resolution (Graham et al., 2021; Yoshida & Smith, 2008). In response, studies have increasingly used head-mounted cameras and eye-tracking technology to capture children's visual experiences in real time during parent-child interaction (Franchak et al., 2011; Smith et al., 2011, 2015; Yoshida & Smith, 2008; Yu & Smith, 2013). Notably, when observed in these interactive contexts, children with autism exhibit *similar* SA and JA experiences to their neurotypical peers (Perkovich & Yoshida, 2024a; Perkovich et al., 2022; Yurkovic et al., 2020, 2021; Yurkovic-Harding et al., 2022), suggesting that the availability and use of social cues from parents may help explain these group similarities (Perkovich et al., 2022; Yoshida et al., 2019).

### 1.2. Variability in parental scaffolding

Parents of children with autism often use distinct scaffolding strategies that reflect adaptive responses to their child's needs, which support attention similarly across diagnostic groups in naturalistic settings (Yoshida et al., 2019). While children with autism and their neurotypical peers may show comparable rates of SA and JA, the parental strategies that predict those outcomes may differ. For example, JA in neurotypical children has been linked to parent attention to objects, while in children with autism, JA has been shown to be more strongly associated with parent attention to the child (Perkovich et al., 2022). Similarly, scaffolding behaviors such as parental object handling and attention to the child's face have been shown to moderate the link between JA and vocabulary development (Perkovich & Yoshida, 2024a). These findings suggest that differences in how parents scaffold attention—not just child behavior—may shape developmental pathways.

This idea aligns with broader developmental work showing that variations in parental responsiveness, synchrony, and referential specificity predict language and communication outcomes across populations (McDuffie & Yoder, 2010; Perkovich & Yoshida, 2024a; Perryman et al., 2013; Siller & Sigman, 2002, 2008). Notably, younger children—such as infants and toddlers—may be especially sensitive to these moment-to-moment scaffolding cues, as they still rely heavily on parent guidance to direct and maintain attention (Burling & Yoshida, 2019; Sun & Yoshida, 2022; Yu & Smith, 2013). Head-mounted camera and eye-tracking studies support this: while attention patterns may appear similar, the underlying scaffolding strategies that sustain these patterns differ (Perkovich et al., 2022; Yoshida et al., 2019; Yurkovic et al., 2020; Yurkovic-Harding et al., 2022).

Emerging evidence from studies of parents of FH+ children has documented distinct interactive behaviors. For instance, these parents tend to engage in more directive, skill-focused behaviors, remain more proximal to the interaction, and differ in synchrony, sensitive responsiveness, and engagement intensity (Srinivasan & Bhat, 2020; Wan et al., 2012; Yirmiya et al., 2006). These patterns have also been associated with divergent development outcomes in domains such as mood, language, and later autism diagnosis (Choi, Nelson, et al., 2020; Choi, Shah, et al., 2020; Kellerman et al., 2020; Steiner et al., 2018; Wan et al., 2013). Of particular relevance, Smith et al. (2023) examined parent-infant interactions via Zoom and with FH+ and FH- families. They found that while parents of FH+ infants often used different strategies—such as increased face-looking prior to JA—their infants ultimately achieved comparable JA outcomes. These findings point to the potential compensatory role of social scaffolding in infancy. Building on this work, the present study measured moment-to-moment SA and JA *directly* during parent-child interaction and linked these gaze patterns to parental scaffolding behaviors. This approach reveals early mechanisms through which social interaction may shape individual differences in developmental pathways (Campbell et al., 2015; Navab et al., 2011; Steiner et al., 2018).

### 1.3. Aims

The present study examined parent-child interactive object play using head-mounted eye trackers worn by both parent and toddler participants. Specifically, we aimed to: (1) measure toddlers' moment-to-moment SA and JA across groups, and we hypothesized that there would be no significant differences between FH+ and FH- toddlers; (2) identify group differences in parental scaffolding behaviors, with the expectation that parents of FH- toddlers would more frequently label and look more at objects, while parents of FH+ toddlers would more often look at their child's face and engage in object handling; and (3) explore how parental scaffolding relates to toddlers' SA and JA, predicting that greater scaffolding—across both groups—would be positively associated with toddlers' attention.

## 2. Material and method

### 2.1. Participants

Thirty-eight parent-child dyads contributed data to the present study, divided into two developmental groups based on genetic likelihood of autism: FH+ and FH-. The FH+ group consisted of 19 toddlers ( $M = 18.98$  months,  $SD = 8.85$  months; 9 male) who had an older sibling with a confirmed autism diagnosis, verified through clinical reports, individualized education programs, or other

**Table 1**  
Participant demographic information

	FH-	FH+	Group Differences
	<i>M (SD) or n</i>	<i>M (SD) or n</i>	<i>p</i>
Age	18.821 (8.844)	18.978 (8.854)	0.87
Toddler Gender			1.00
Male	10	10	
Female	9	9	
Toddler Race/Ethnicity			0.24
Hispanic	6	7	
White	7	2	
Asian	3	2	
Black or African American	1	4	
Biracial	2	4	
Participating Parent Gender			0.97
Male	0	1	
Female	19	18	
Participating Parent Race/Ethnicity			0.39
Hispanic	7	10	
White	7	3	
Asian	3	2	
Black or African American	1	4	
Biracial	1	0	
Socioeconomic Status			
Family Income	\$135,791 (\$82,185)	\$62,827 (\$31,093)	<b>0.01</b>
Years of Maternal Education	16.267 (2.463)	14.357 (2.405)	0.05
Years of Paternal Education	17.000 (2.238)	13.692 (3.038)	<b>0.01</b>
Toddler Autism Screening			
ESAT	0.533 (0.743)	5.750 (4.559)	< .01
M-CHAT-R/F	0.500 (0.730)	7.667 (6.314)	< .01
Participating Parent Depression Symptoms	0.605 (0.726)	0.713 (0.770)	0.61
Participating Parent Broad Autism Phenotype			
Total	2.482 (0.550)	3.066 (0.667)	<b>0.01</b>
Aloofness	2.519 (0.934)	3.179 (0.726)	<b>0.02</b>
Pragmatic Language	2.132 (0.412)	2.667 (1.002)	<b>0.03</b>
Rigidity	2.794 (0.573)	3.351 (0.953)	<b>0.02</b>
Toddler Vocabulary			
Receptive Vocabulary	54.277 % (44.653)	36.195 % (47.172)	0.32
Productive Vocabulary	21.654 % (31.996)	18.057 % (33.544)	0.77

**Note.** Toddler autism symptoms were assessed using the Early Screening of Autistic Traits (ESAT) (Swinkels et al., 2006) for all participants and the Modified Checklist for Autism Traits - Revised Follow-Up (M-CHAT-R/F) (Robins et al., 2014) for participants between 16 and 30 months old. Socioeconomic status (family income, maternal education, and paternal education) was measured through a modified John D. and Catherine MacArthur Socioeconomic Status (SES) form (Galvan et al., 2023). Parental depression symptoms were assessed through the use of the Hopkins Symptom Checklist-10 (HSCL-10) (Derogatis et al., 1974). Parental broad autism phenotype was assessed using 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. Toddler vocabulary was assessed using the MacArthur-Bates Communicative Developmental Inventory (MCDI); receptive and expressive vocabulary was measured for participants 18 months and younger using the Words and Gestures version, while productive vocabulary was measured for participants 19 months and older - scores are reported as the percentage of words indicated by the parent that the child can understand (receptive) and produce (productive) (Fenson et al., 2007).

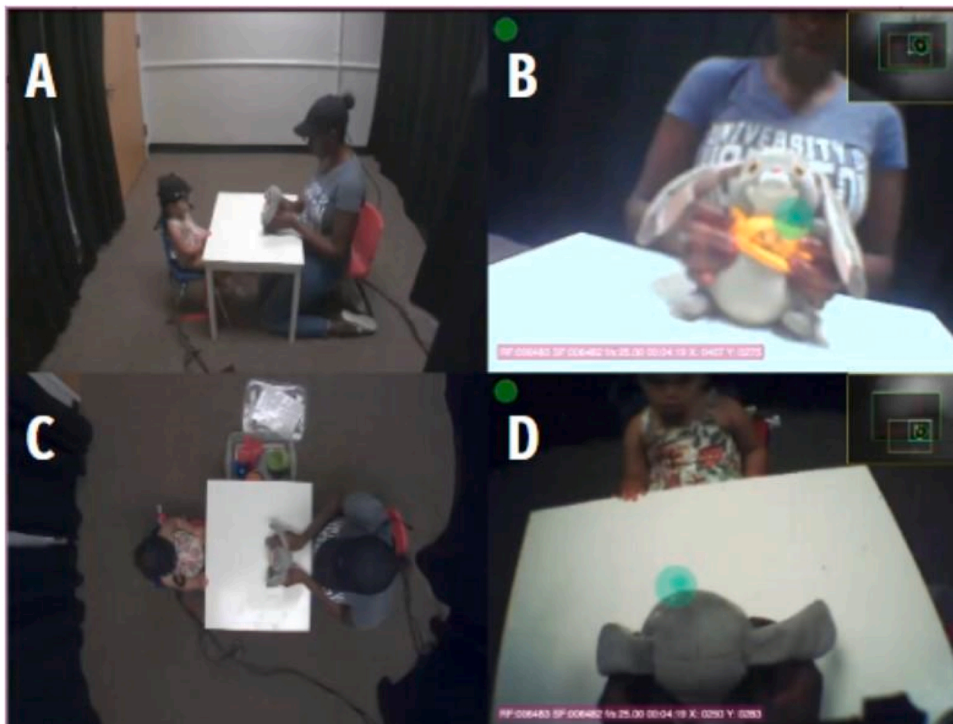
diagnostic documentation. The FH- group included 19 age- and sex-matched toddlers ( $M = 18.82$  months,  $SD = 8.84$  months; 9 male) with no known developmental conditions and no first- or second-degree biological relatives diagnosed with autism. All toddlers were full-term at birth ( $\geq 38$  weeks or  $> 2.41$  kg), between 9 and 28 months of age at the time of the study visit, had no documented hearing or visual impairments, and were primarily exposed to English at home. Additionally, all parents reported no autism diagnosis or psychiatric conditions. FH- families reported higher average family income and parental education (both maternal and paternal) compared to FH+ families. In contrast, FH+ toddlers had significantly higher scores on both autism screening measures - the Early Screening for Autistic Traits (ESAT) (Swinkels et al., 2006) and the Modified Checklist for Autism in Toddlers, Revised with Follow-Up (M-CHAT-R/F) (Robins et al., 2014). FH+ parents also reported significantly higher scores on the Broad Autism Phenotype Questionnaire (BAPQ) (Hurley et al., 2007) total score as well as the aloofness, pragmatic language, and rigidity subscales. See Table 1 for extended demographic information.

The sample size is comparable to other naturalistic play studies investigating group differences in child and parent behaviors, including those utilizing head-mounted eye-tracking methodologies (Magrelli et al., 2013; Perkovich et al., 2022; Slonims & McConachie, 2006; Smith et al., 2023; Sun et al., 2022; Yoshida et al., 2019; Yurkovic et al., 2021; Yurkovic-Harding et al., 2022). Three additional FH+ dyads were excluded due to toddler fussiness ( $n = 1$ ) or inadequate recording quality ( $n = 2$ ; e.g., camera angle misalignment preventing accurate gaze capture or insufficient calibration).

## 2.2. Procedures

Upon arrival at the university lab, parent participants provided informed consent before proceeding to the experimental room, where the play session took place. Each parent dyad completed a 5-minute and 20-second semi-naturalistic object play session using eight unique toy objects—these parameters (e.g., the play session length and the number of toy objects) are consistent with prior head-mounted eye-tracking studies involving neurotypical toddlers during parent-child play (Borjon et al., 2021; Deák et al., 2008; MacNeill et al., 2021; Perkovich & Yoshida, 2024b; Sun & Yoshida, 2022; Sun et al., 2022; Tamis-LeMonda et al., 2014; Yu & Smith, 2013, 2017a). During the session, parents and toddlers sat across from each other at a  $60\text{ cm} \times 60\text{ cm}$  table, both wearing head-mounted eye trackers. Calibration was conducted before and after the session by trained research assistants. Parent participants were instructed to engage with their child as naturally as they would at home, with the freedom to introduce toys at any time, either one at a time or in combination. The entire procedure—including set-up, calibrations, and the play—lasted 20–30 min.

For FH+ toddlers, data collection followed established recommendations for working with FH+ children (Perkovich et al., 2024), including a stepwise acclimation process to the equipment, modeling, and positive reinforcement. These accommodations were designed to support successful data collection and did not influence the attention or scaffolding behaviors observed.



**Fig. 1.** Video set-up for behavioral annotation of the parent-child play session. **Note.** (A) Wall-mounted view of the parent-child play session. (B) First-person view from the toddler's head-mounted eye tracking. (C) Ceiling-mounted camera view of the parent-toddler play session. (D) First-person view from the parent's head-mounted eye tracking. The blue fixation dot represents the participant's gaze in each video frame.

As appreciation, all families received a gift card, two family passes to a local children's museum, and an age-appropriate T-shirt, stuffed animal, or book. The study and all procedures were approved by the university's Institutional Review Board where the research took place.

### 2.3. Equipment

Sessions were recorded using Watec (WAT-230A) miniature color cameras with Positive Sciences, Inc. eye-trackers (Franchak et al., 2011). Each 51 g system had two cameras: one capturing the right eye's pupil and corneal reflection, and another mounted on the forehead recording the first-person view (FPV: 54.4° horizontal by 42.2° vertical). To ensure unrestricted movement during the session, both cameras were connected via long, lightweight cables that allowed for participants' natural engagement in play.

Calibration was conducted before and after the play session using a manual calibration process, which lasted approximately one minute per participant. A 60 × 40 cm calibration board with nine spatially distributed stickers was placed in front of each participant. Trained research assistants directed participants' attention to each sticker in a random order—pointing to stickers for parents and using a salient toy (e.g., a small rattle) for toddlers to capture their gaze. Calibration accuracy was assessed post hoc using the Yarus software program, which estimated the participant's eye gaze relative to their visual scene. A minimum calibration correlation of 0.85 was required for inclusion in the dataset (Sun & Yoshida, 2022; Sun et al., 2022).

Two additional digital video cameras, mounted on the wall and ceiling, provided an overall view of the play session along with an audio recording. These wall and ceiling views facilitated the behavioral annotation process for parental object handling (see Section 2.4. for details). All videos were recorded at 30 frames per second and synchronized using Adobe Premiere.

Each dyad contributed an average of 8268.14 frames ( $SD = 674.44$ ), which aligns with previously conducted head-mounted eye-tracking studies of similar play session lengths (Perkovich et al., 2022; Sun et al., 2022). Frames affected by blinks, fussiness, and interruptions were excluded.

### 2.4. Behavioral annotation

Recordings were imported into the Datavyu software program (Datavyu Team, 2014), where trained research assistants manually annotated target variables frame-by-frame. See Fig. 1 for an example of the video setup and Supplementary Fig. 1 for an example visualization of the behavioral annotation streams. Each behavior described below was quantified using three measures: (1) frequency per minute, (2) overall duration, and (3) percentage of play session time spent engaging in the behavior.

#### 2.4.1. Toddlers' attention

We coded toddler and parent gaze patterns separately, focusing on toddlers' attention to objects and parents' attention to objects and their toddlers' faces. Toddler SA to objects was defined as maintaining gaze on the same object for at least 2000 ms, a threshold that reflects extended or focused looking (Frick et al., 1999; Kannass et al., 2006; Perkovich & Yoshida, 2024a; Perkovich et al., 2022; Sun et al., 2022, 2023).

To identify JA, we synchronized the toddler and parent data streams, capturing moments when both looked at the same object simultaneously for at least 500 ms. Consistent with prior head-mounted eye-tracking studies, we allowed brief looks away (less than 300 ms) during JA instances to maintain a comprehensive approach (Smith et al., 2023; Yu & Smith, 2017a; Yurkovic-Harding et al., 2022). This approach to JA measurement aligns with the nature of our research questions and is consistent with methods used by recent head-mounted eye-tracking studies focusing on JA (Smith et al., 2023; Yu & Smith, 2017a; Yurkovic-Harding et al., 2022), with studies revealing several multimodal pathways for establishing parent-child JA (Smith et al., 2015, 2023; Sun et al., 2022; Yu & Smith, 2013, 2017a; Yurkovic-Harding et al., 2022) that differ from the traditionally established perspective of explicit, triadic gaze shifts from the face (Corkum & Moore, 1998; Moore, 1995; Mundy & Gomes, 1998; Mundy & Jarrold, 2010; Mundy et al., 1990; Mundy, 2017).

#### 2.4.2. Parental scaffolding

We measured four types of parental scaffolding behaviors: (1) parent naming objects (verbal labelling of objects), (2) parent handling objects (physical engagement with objects), (3) parent attention to an object (gazing at an object for at least 500 ms), and (4) parent attention to their toddler's face (gazing at their child's face for at least 500 ms). These behaviors have been separately and collectively linked to socially coordinated attention in both neurotypical toddlers and children with autism (Burling & Yoshida, 2019; Perkovich et al., 2022; Suarez-Rivera et al., 2019; Sun & Yoshida, 2022; Yu & Smith, 2016).

### 2.5. Data analysis approach

To examine the group differences in toddler visual experiences (SA and JA) and in parental scaffolding behaviors, we conducted analysis of covariance (ANCOVA) models, with toddler age and sex as covariates. Each construct (e.g., object naming, object handling, visual attention) was assessed across three metrics: frequency per minute, overall duration, and proportion of the play session. To assess the relationship between parental scaffolding behaviors and toddler attention, we used multiple linear regression models for our frequency and proportion variables. For duration variables, which included repeated or continuous data distributions, we used linear mixed-effects models with participant ID included as a random effect. All regression and mixed models included developmental group (FH+ vs. FH-), toddler age and sex as predictors. Age and sex were included as covariates based on growing evidence that both factors

are associated with variation in early attention patterns and parental scaffolding behaviors during play (Clearfield & Nelson, 2006; Kruper & Uzgiris, 1987; O'Brien & Nagle, 1987; Perkovich & Yoshida, 2024b; Sun et al., 2022). Each model also included an interaction term between developmental groups and the relevant parental scaffolding behavior to test whether associations between scaffolding and toddler attention differed by group. When the interaction term was significant, we conducted simple slopes analyses to probe group-specific associations. An alpha level of 0.05 was used to determine statistical significance. Summary statistics for each targeted variable are presented in Table 2.

### 3. Results

Our models identified three key findings: (1) the effect of developmental group on toddlers' looking behaviors, (2) the effect of developmental group on parental behaviors, and (3) the extent to which parental social scaffolding behaviors predict toddlers' attention behaviors. First, there were no group differences in JA or SA between FH+ and FH- toddlers (all  $p$ -values < .05). Second, parents of FH+ toddlers looked more at objects whereas parents of FH- toddlers engaged in more object naming and looked more at their toddler's face. Third, parental object-looking predicted JA, while parental object handling predicted SA across both developmental groups. However, the relationship between parent object handling and JA was moderated by developmental group: greater object handling predicted more JA only among FH- toddlers.

#### 3.1. Toddler looking behaviors

No significant main effects on toddler SA were found for developmental group, toddler sex, or toddler age. See Supplementary Table 1 for full statistical results and Supplementary Fig. 2 for a visualization of the group comparisons.

No significant main effects on JA were observed for developmental group, toddler sex, or age. See Supplementary Table 1 for full statistical results and Supplementary Fig. 2 for a visualization of the group comparisons.

#### 3.2. Parent scaffolding behaviors

##### 3.2.1. Parent naming objects

A significant main effect of the developmental group was found: parents of FH- toddlers named objects more frequently, ( $F(1,34) = 0.152$ ,  $p = 0.017$ ,  $\eta^2 = 0.152$ , 95 % CI = [-6.492, - 0.665]), spent more time naming objects ( $F(1,34) = 0.329$ ,  $p < 0.001$ ,  $\eta^2 = 0.329$ , 95 % CI = [-39.350, - 13.452]), and dedicated a greater proportion of the play session to object naming ( $F(1,34) < 0.001$ ,  $p = 0.317$ ,  $\eta^2 = 0.317$ , 95 % CI = [-0.110, - 0.036]) compared to parents of FH+ toddlers. See Supplementary Table 1 for full statistical results and Fig. 2 for a visualization of the group differences.

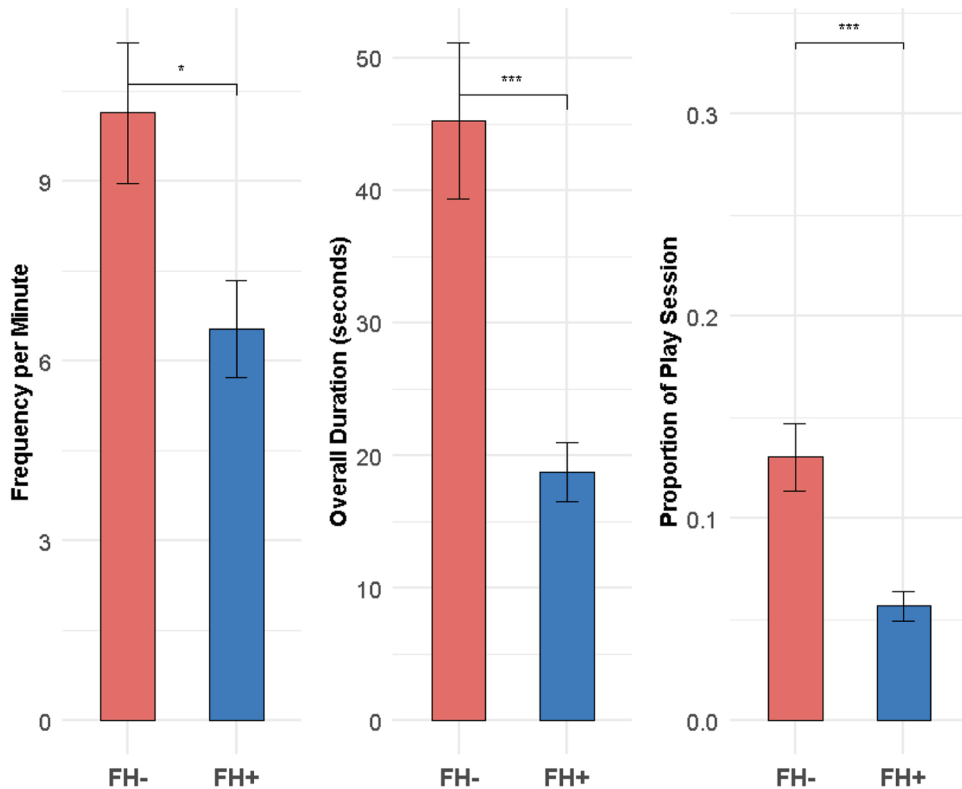
##### 3.2.2. Parent handling objects

No significant main effects on parental object handling were found for developmental group, toddler sex, or age. See Supplementary Table 1 for full statistical results and Supplementary Fig. 3 for a visualization of the group comparisons.

**Table 2**

Association of SA and parent object handling.

	<i>B</i>	<i>SE</i>	<i>t</i>	<i>p</i>	$\beta$	Confidence Interval (95 %)
<b>Frequency per Minute</b>						
Developmental Group	2.053	2.385	0.861	0.396	- 0.280	[- 2.825, 6.930]
Object Handling Frequency	0.128	0.062	2.050	<b>0.049</b>	0.210	[0.001, 0.255]
Toddler Age	0.038	0.071	0.540	0.594	0.090	[- 0.107, 0.183]
Toddler Sex	- 0.148	1.125	- 0.132	0.896	- 0.020	[- 2.450, 2.154]
Overall Object Looking	0.003	0.008	0.308	0.760	0.760	[- 0.015, 0.020]
Developmental Group * Object Handling Frequency	- 0.156	0.086	- 1.809	0.081	0.081	[- 0.333, 0.020]
<b>Overall Duration</b>						
Developmental Group	0.110	0.598	0.184	0.856	0.08	[- 0.967, 1.141]
Object Handling Duration	- 0.001	0.002	- 0.399	0.694	- 0.02	[- 0.003, 0.002]
Toddler Age	- 0.002	0.016	- 0.045	0.965	- 0.01	[- 0.030, 0.020]
Toddler Sex	0.151	0.229	0.657	0.518	0.04	[- 0.280, 0.544]
Overall Object Looking	- 0.002	0.002	- 0.822	0.418	- 0.06	[- 0.006, 0.002]
Developmental Group * Object Handling Duration	0.001	0.002	0.329	0.746	0.02	[- 0.003, 0.005]
<b>Proportion of Play Session</b>						
Developmental Group	0.372	0.242	1.540	0.134	- 0.12	[- 0.121, 0.865]
Object Handling Proportion	0.458	0.231	1.984	0.056	0.19	[- 0.013, 0.929]
Toddler Age	- 0.001	0.005	- 0.080	0.937	- 0.02	[- 0.010, 0.009]
Toddler Sex	- 0.051	0.074	- 0.691	0.495	- 0.13	[- 0.203, 0.100]
Overall Object Looking	- 0.008	0.247	- 0.033	0.974	- 0.01	[- 0.512, 0.496]
Developmental Group * Object Handling Proportion	- 0.574	0.322	- 1.785	0.084	- 0.32	[- 1.231, 0.082]



**Fig. 2.** Group differences in parent naming objects measurements. **Note.** Parents of FH- toddlers named objects more frequently per minute ( $p = 0.017$ ), spent more time naming objects ( $p < 0.001$ ) and dedicated a greater proportion of the play session to object naming ( $p < 0.001$ ) compared to parents of FH+ toddlers.

### 3.2.3. Parent Looking at Objects

A significant main effect of developmental group was found, ( $F(1,34) = 0.093$ ,  $p = 0.039$ ,  $\eta^2 = 0.093$ , 95 % CI = [0.126, 7.862]), with parents of FH+ toddlers looking at objects more frequently than parents of FH- toddlers. Additionally, parents of older toddlers looked at objects more frequently than parents of younger toddlers ( $F(1,34) = 0.105$ ,  $p = 0.029$ ,  $\eta^2 = 0.105$ , 95 % CI = [0.020, 0.495]). Finally, a significant effect of toddler sex was observed, with parents of female toddlers looking at objects more frequently, for longer durations, and spending a greater proportion of the play session engaged in object looking ( $F(1,34) = 0.123$ ,  $p = 0.018$ ,  $\eta^2 = 0.123$ , 95 % CI = [0.865, 8.612];  $F(1,34) = 0.109$ ,  $p = 0.041$ ,  $\eta^2 = 0.109$ , 95 % CI = [1.41, 65.549]; and  $F(1,34) = 0.132$ ,  $p = 0.022$ ,  $\eta^2 = 0.132$ , 95 % CI = [0.017, 0.196], respectively). See [Supplementary Table 1](#) for full statistical results and [Fig. 3](#) for a visualization of the group differences.

### 3.2.4. Parent looking at toddler face

A significant main effect of developmental group was found, with parents of FH- toddlers looking at their toddler's face more frequently than parents of FH+ toddlers, ( $F(1,34) = 0.127$ ,  $p = 0.032$ ,  $\eta^2 = 0.127$ , 95 % CI = [-8.276, -0.411]). See [Table 2](#) for full statistical results and [Fig. 4](#) for a visualization of the group differences.

## 3.3. Influence of Parental Social Scaffolding on Toddler Visual Experiences

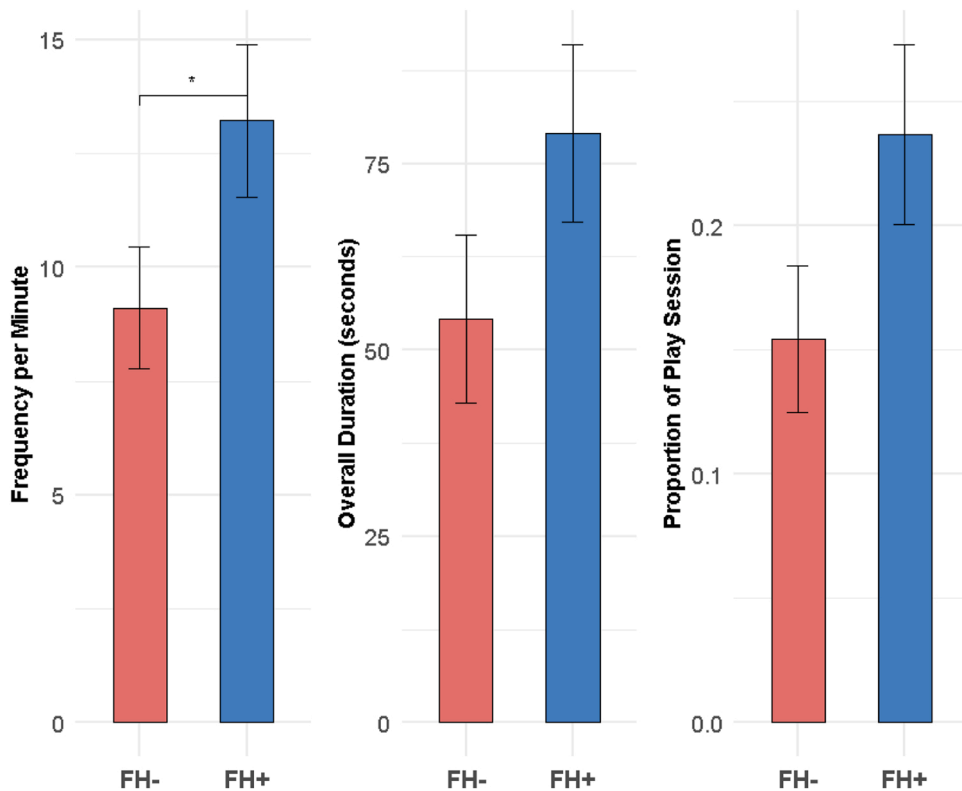
### 3.3.1. SA

In regard to parent object naming, parent looking at objects, and parent looking at their toddler's face, there were no main group effects or interaction effects between the respective scaffolding behavior and developmental group found. See [Supplementary Table 2–4](#) respectively for full statistical results.

A significant main effect was found for the frequency of parent object handling per minute on toddler SA ( $B = 0.128$ ,  $SE = 0.062$ ,  $t = 2.050$ ,  $p = 0.049$ ). However, no main effects were found for duration or proportion, and no interaction effects between parent object handling and developmental group were found. See [Table 2](#) for full statistical results.

### 3.3.2. JA

In regard to parent object naming and parent looking at their toddler's face, there were no main group effects or interaction effects between the respective scaffolding behavior and developmental group found. See [Supplementary Table 5 and 6](#), respectively, for full



**Fig. 3.** Group differences in parent looking at objects measurements. **Note.** Parents of FH+ toddlers looked at objects more frequently than parents of FH- toddlers ( $p = 0.039$ ). However, no significant differences were found in the total duration or proportion of the play session spent looking at objects.

statistical results.

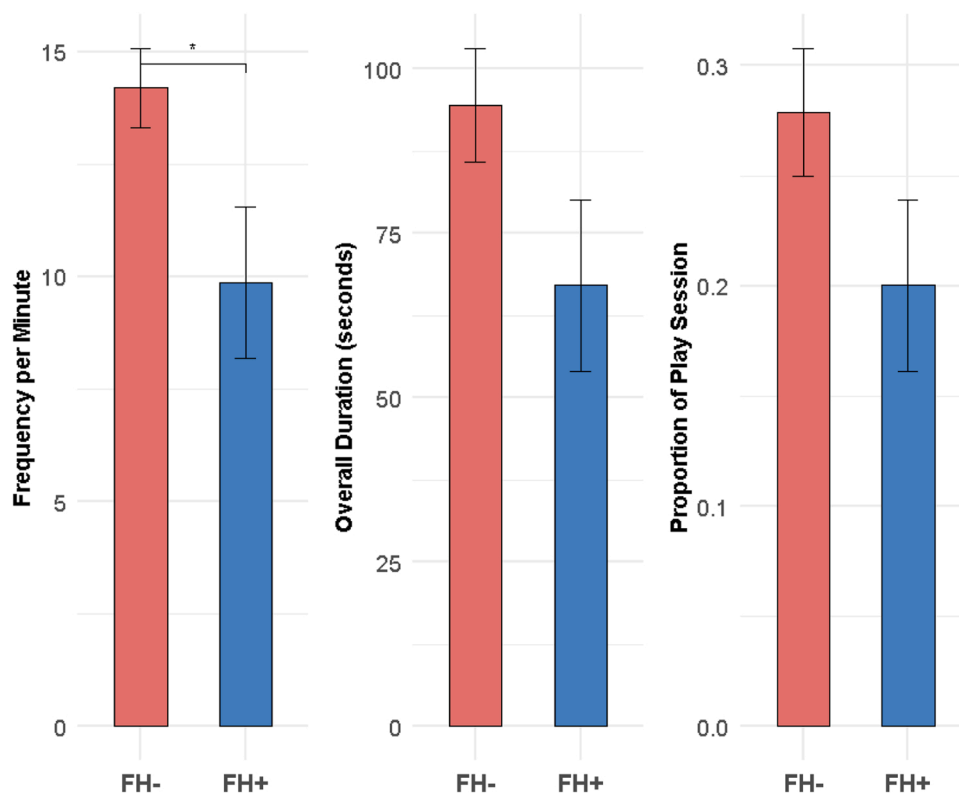
A significant main effect was found for the frequency of parent object handling per minute on toddler JA ( $B = 0.098$ ,  $SE = 0.043$ ,  $t = 2.273$ ,  $p = 0.030$ ), indicating that toddlers demonstrated more JA when their parents engaged in more object handling. No significant main effects were found for duration or proportion. See Table 3 for full statistical results.

We also found a significant interaction effect between the developmental group and parental object handling ( $B = -0.141$ ,  $SE = 0.059$ ,  $t = -2.377$ ,  $p = 0.024$ ). To further explore this relationship, we conducted a post hoc simple slopes analysis to examine the relationship between parent object handling and JA within each developmental group. For FH- group, there was a significant positive association between parental object handling and JA ( $b = 0.146$ ,  $se = 0.053$ ,  $t = 2.732$ ,  $p = 0.010$ ). However, no significant association was found between parental object handling and JA among FH+ toddlers ( $b = -0.027$ ,  $se = 0.056$ ,  $t = -0.490$ ,  $p = 0.628$ ). In other words, developmental group moderated the relationship between parental object handling and JA. More frequent parental object handling was associated with increased JA among FH- toddlers, whereas no significant relationship was observed among FH+ toddlers.

A significant main effect of the frequency of parent object looking per minute on toddler SA ( $B = 0.193$ ,  $SE = 0.088$ ,  $t = 2.198$ ,  $p = 0.036$ ), indicating that toddlers demonstrated more frequent JA when their parents more frequently looked at objects. No significant main effects were found for duration or proportion, and no interaction effects between parent object looking and developmental group were found. See Table 4 for full statistical results.

#### 4. Discussion

This study examined how early attentional behaviors—specifically, SA and JA—are shaped within naturalistic parent–child interactions in toddlers with and without a family history of autism. Using head-mounted eye tracking, we assessed group-level similarities and differences in toddler attention, variations in parental scaffolding, and how specific scaffolding behaviors support attention in real time. We found no group differences in SA or JA, but parents of FH- toddlers used more verbal scaffolding and face-directed attention, while FH+ parents focused more on objects. Parental object handling predicted toddler SA, and both object handling and object looking predicted JA. These findings offer new insights into how parent scaffolding shapes attention early in development across diverse developmental trajectories.



**Fig. 4.** Group differences in parent looking at toddler face measurements. **Note.** Parents of FH- toddlers looked at their toddler's face more frequently than parents of FH+ toddlers ( $p = 0.032$ ). However, no significant differences were found in the duration or proportion of the play session spent looking at objects.

**Table 3**

Association of JA and parent object handling.

	<i>B</i>	<i>SE</i>	<i>t</i>	<i>p</i>	$\beta$	Confidence Interval (95 %)
<b>Frequency per Minute</b>						
Developmental Group	3.658	1.646	2.167	<b>0.038</b>	0.01	[0.210, 6.925]
Object Handling Frequency	0.098	0.043	2.273	<b>0.030</b>	0.15	[0.010, 0.186]
Toddler Age	0.029	0.048	0.599	0.554	0.10	[- 0.069, 0.126]
Toddler Sex	0.591	0.757	0.780	0.441	0.12	[- 0.953, 2.134]
Overall Object Looking	0.006	0.006	0.960	0.344	0.17	[- 0.006, 0.017]
Developmental Group * Object Handling Frequency	- 0.141	0.059	- 2.377	<b>0.024</b>	- 0.39	[- 0.262, - 0.020]
<b>Overall Duration</b>						
Developmental Group	- 0.083	0.238	- 0.350	0.729	- 0.05	[- 0.519, 0.336]
Object Handling Duration	- 0.001	0.001	- 0.688	0.497	- 0.05	[- 0.001, 0.001]
Toddler Age	- 0.003	0.006	- 0.454	0.654	- 0.03	[- 0.012, 0.008]
Toddler Sex	0.038	0.085	0.445	0.661	0.03	[- 0.118, 0.186]
Overall Object Looking	0.001	0.001	1.135	0.267	0.07	[- 0.001, 0.003]
Developmental Group * Object Handling Duration	0.001	0.001	0.026	0.979	0.01	[- 0.002, 0.002]
<b>Proportion of Play Session</b>						
Developmental Group	- 0.013	0.049	- 0.274	0.786	- 0.09	[- 0.114, 0.087]
Object Handling Proportion	0.001	0.001	0.213	0.833	0.04	[- 0.002, 0.002]
Toddler Age	- 0.004	0.015	- 0.254	0.801	- 0.04	[- 0.035, 0.027]
Toddler Sex	- 0.001	0.047	- 0.024	0.981	0.01	[- 0.097, 0.095]
Overall Object Looking	0.149	0.050	2.961	0.006	0.55	[0.046, 0.252]
Developmental Group * Object Handling Proportion	0.008	0.066	0.116	0.909	0.02	[- 0.126, 0.141]

#### 4.1. Contextualizing group-level patterns of attention

Our results align with recent studies showing comparable visual attention in children with autism and one study of FH+ infants, relative to neurotypical peers, during naturalistic interactions (Perkovich et al., 2022; Smith et al., 2023; Yurkovic et al., 2020, 2021; Yurkovic-Harding et al., 2022), in contrast to earlier work using computer-based tasks that reported reduced JA in FH+ infants and

**Table 4**  
Association of JA and parent object looking.

	<i>B</i>	<i>SE</i>	<i>t</i>	<i>p</i>	$\beta$	Confidence Interval (95 %)
<b>Frequency per Minute</b>						
Developmental Group	− 1.141	1.388	− 0.821	0.418	− 0.18	[− 3.972, 1.691]
Object Looking Frequency	0.193	0.088	2.198	<b>0.036</b>	0.58	[0.014, 0.373]
Toddler Age	0.015	0.045	0.336	0.739	0.05	[− 0.076, 0.106]
Toddler Sex	− 0.403	0.739	− 0.545	0.590	− 0.08	[− 1.910, 1.105]
Overall Object Looking	0.007	0.005	1.467	0.153	0.22	[− 0.003, 0.017]
Developmental Group * Object Looking Frequency	0.025	0.109	0.228	0.822	0.04	[− 0.198, 0.248]
<b>Overall Duration</b>						
Developmental Group	− 0.355	0.155	− 2.290	<b>0.030</b>	− 0.05	[− 0.625, − 0.075]
Object Looking Duration	− 0.001	0.002	− 0.097	0.924	0.10	[− 0.004, 0.003]
Toddler Age	− 0.003	0.005	− 0.594	0.558	− 0.03	[− 0.012, 0.006]
Toddler Sex	− 0.030	0.080	− 0.382	0.706	− 0.02	[− 0.176, 0.106]
Overall Object Looking	0.001	0.001	0.139	0.890	0.01	[− 0.002, 0.002]
Developmental Group * Object Looking Duration	0.004	0.002	1.865	0.076	0.11	[0.001, 0.007]
<b>Proportion of Play Session</b>						
Developmental Group	− 0.034	0.024	− 1.407	0.170	− 0.08	[− 0.083, 0.015]
Object Handling Proportion	− 0.087	0.100	− 0.870	0.391	− 0.06	[− 0.291, 0.117]
Toddler Age	− 0.001	0.001	− 0.024	0.982	− 0.01	[− 0.002, 0.002]
Toddler Sex	− 0.008	0.015	− 0.515	0.612	− 0.08	[− 0.038, 0.023]
Overall Object Looking	0.172	0.065	0.065	<b>0.014</b>	0.63	[0.039, 0.305]
Developmental Group * Object Looking Proportion	0.134	0.103	0.103	0.203	0.22	[− 0.076, 0.345]

toddlers compared to FH- peers (Nyström et al., 2019; Presmanes et al., 2007; Thorup et al., 2016). A critical distinction lies in the methodological context: the earlier studies typically measured attention in isolated, screen-based settings focused on face- or gaze-following behaviours, which may not reflect the broader social context in which attention develops. In addition to this contextual shift, our study also adopted a broader operationalization of JA—defined as shared object engagement regardless of whether it was initiated by gaze or manual actions. This aligns with growing evidence—much of it from studies of children with autism and one from FH+ populations—suggesting that JA can emerge through multiple modalities, including gaze and manual actions (Perkovich & Yoshida, 2024a; Perkovich et al., 2022; Smith et al., 2023; Yoshida et al., 2019; Yurkovic-Harding et al., 2022). Manual actions, particularly object handling, are salient cues for attention direction (Burling & Yoshida, 2019; Deák et al., 2014; Sun et al., 2024; Yu & Smith, 2013, 2017a, 2017b) and may serve as developmental precursors to gaze-following (Boyer et al., 2020). This inclusive JA framework not only aligns with emerging evidence of multimodal attention coordination in early development, but also opens new opportunities to detect experience-specific variation in how attention is initiated and maintained. For example, although overall JA rates may appear similar, prior research indicates that FH+ infants show fewer infant-led JA episodes than FH- peers, despite similar rates of parent-led JA (Smith et al., 2023). This pattern suggests emerging divergence in child-initiated engagement, which may be especially important in understanding early developmental variation. Our findings provide a foundation for future work examining how parental scaffolding supports (or limits) child-initiated attention and how such dynamics evolve over time.

#### 4.2. Mechanisms of scaffolding and their differential impact

Our findings revealed distinct scaffolding strategies across groups. Parents of FH- toddlers engaged in more verbal scaffolding (e.g., object naming) and face-directed attention, whereas FH+ parents focused more on objects. This differs from some prior work on parents of children with autism, who often increase face-directed behavior to support engagement (Perkovich et al., 2022; Yoshida et al., 2019). One possibility is that FH+ parents may not yet perceive a need to adapt interactions, whereas parents of children with a diagnosis may adopt strategies aimed at supporting engagement. This may reflect a developmental shift in scaffolding, with face-directed behaviors emerging later as compensatory mechanisms once children are older and diagnostic clarity increases. Alternatively, differences in exposure to early intervention may also play a role. Parents of children with autism often receive clinical guidance on promoting engagement (e.g., applied behavior analysis therapy) (Martins & Harris, 2006; Monlux et al., 2019; Murza et al., 2016; Taylor & Hoch, 2008; Weisberg & Jones, 2019). In contrast, FH+ parents—though they had an older diagnosed child—may not apply the same strategies with their younger children (Regehr & Feldman, 2009). These differences highlight how scaffolding can be shaped by both experience and context, raising questions about whether and how intervention strategies applied with one child influence scaffolding styles with another, particularly given documented variability in parents' recognition of autism-related behaviors (Cleary et al., 2024; De Giacomo & Fombonne, 1998; Glascoe, 2003; Hess & Landa, 2012; McMahon et al., 2007; Ozonoff et al., 2009).

In addition to these group-level differences in scaffolding style, we also examined how specific parent behaviors predicted SA and JA outcomes. Parental object handling predicted SA across both groups, while it predicted JA only in FH- toddlers. This distinction may reflect the different demands of SA and JA: SA involves self-initiated engagement that can be stabilized by object interaction—such as reaching and handling—which has been shown to extend visual attention during early play (Yoshida & Smith, 2008; Yu & Smith, 2016). In contrast, JA involves not just attending an object, but knowing that both partners are attending together—a triadic structure requiring coordination and mutual awareness (Carpenter et al., 1998; Tomasello, 1995). Consistent with prior research, parental

object-looking predicted JA in both groups, reinforcing the importance of parental visual cues in guiding infant attention and supporting shared experiences (Deák et al., 2014; Suarez-Rivera et al., 2019; Sun & Yoshida, 2022; Sun et al., 2022; Yu & Smith, 2013, 2015, 2017a, 2017b). In neurotypical populations, combinations of scaffolding cues—such as simultaneous naming and handling—enhance attentional engagement more effectively than single cues (Deák et al., 2018; Suarez-Rivera et al., 2019; Sun et al., 2022; Zukow-Goldring, 1996). However, our findings indicate that the effectiveness of specific scaffolding strategies—such as object handling—may not be uniform across developmental groups. While these strategies supported both SA and JA in FH- toddlers, their influence on JA was less apparent in FH+ toddlers. This divergence suggests that the same parental behaviors may be interpreted or integrated differently depending on the child's attentional profile, indicating the importance of individual variability in how toddlers respond to scaffolding. Lastly, although we examined only a subset of scaffolding behaviors related to moment-to-moment attention, other interactive behaviors such as gestures, speech, and affective qualities (Choi et al., 2020a; Kellerman et al., 2020; Srinivasan & Bhat, 2020; Steiner et al., 2018; Wan et al., 2012; Wan et al., 2013; Yirmiya et al., 2006) - even those without group differences (Campbell et al., 2015; Choi et al., 2020b; Pijl et al., 2021) - may influence attention development through distinct pathways. These insights help clarify how specific parental behaviors support early attention across groups and underscore the need for developmentally informed approaches that reflect the diversity of attentional styles in early development.

#### 4.3. Limitations and future directions

Several limitations offer important context for interpreting the current findings and point to future directions. First, while the sample size was appropriate for addressing the study aims and is consistent with prior work using similar play paradigms (Burling & Yoshida, 2019; Magrelli et al., 2013; Perkovich et al., 2022; Slonims & McConachie, 2006; Smith et al., 2023; Sun et al., 2022; Yurkovic et al., 2021; Yurkovic-Harding et al., 2022), we did not explicitly examine diversity in socioeconomic status or language exposure—both of which can influence how parents scaffold attention and communicate with young children (Koşkulu et al., 2021; Sun et al., 2022). Although our sample did not include sufficient variation or statistical power to analyze these background factors meaningfully, future work should consider these dimensions to better understand how scaffolding strategies adapt to diverse developmental contexts.

This study also focused on toddlers with a family history of autism rather than formal diagnoses. While parental screening tools (e.g., M-CHAT-R/F, ESAT) were used, observational assessments like the Autism Diagnostic Observation Schedule, Second Edition (ADOS-2) (Lord et al., 2012) could provide more nuanced insights into early traits and behaviors. Similarly, although none of the participating parents had an autism diagnosis, subclinical traits associated with the broad autism phenotype (BAP) may shape interaction styles and responsiveness (Condy et al., 2019; DeLucia et al., 2022; Flippin & Watson, 2018). In the present sample, parents of FH+ infants had significantly higher BAPQ scores compared to parents of FH- infants, consistent with previous literature on the BAP in first-degree relatives of individuals with autism (Hurley et al., 2007; Sasson et al., 2013). These elevated traits may help explain some of the group differences in scaffolding behaviors observed in the present study; particularly relevant findings include increased parental focus on objects and reduced attention to their toddler's face. Given that the primary aim of this study was to characterize scaffolding patterns across infant developmental groups, we did not include BAPQ scores as a covariate in the present analyses. However, exploring the specific contribution of interaction styles remains an important direction for future research (Perkovich & Yoshida, 2025).

Finally, while our primary focus was on parental behaviors, attention is inherently co-constructed through dynamic interactions among toddlers, parents, and the surrounding environment. Toddler contributions (e.g., object handling) and contextual factors (e.g., object salience, and settings such as home vs. lab) likely interact with how scaffolding unfolds in real-time (Bradshaw et al., 2023; Burling & Yoshida, 2019; Sun et al., 2024; Yoshida & Smith, 2008). Additionally, the number of toys available during the play session can serve as a potential scaffolding strategy, as parents can control the number of toys on the table, which can influence the opportunities for SA and JA (Koşkulu et al., 2021). While this was not analyzed in the present study, future research could explicitly investigate how toy availability interacts with parental behaviors to support and redirect attention. These considerations point to promising directions for future work aimed at capturing the dynamic, bidirectional, context-sensitive, and ecologically valid nature of early attention experiences.

## 5. Conclusion

Understanding early visual experiences among FH+ toddlers in social contexts is essential for uncovering the mechanisms that shape attention more broadly. This study provides new evidence that group-level differences in parental scaffolding may contribute to similar rates of SA and JA in FH+ and FH- toddlers during interactive play. These findings build on growing research examining how scaffolding varies across neurodivergent populations and highlight how toddlers actively integrate parental cues to guide attention in real time. By integrating head-mounted eye-tracking with detailed coding of parental scaffolding during naturalistic play, this study offers a novel lens on how moment-to-moment interactions shape early attention—particularly in toddlers with elevated likelihood of autism.

### CRediT authorship contribution statement

**Elizabeth Perkovich:** Writing – original draft, Visualization, Project administration, Formal analysis, Data curation, Conceptualization. **Hanako Yoshida:** Writing – review & editing, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Sarah Mire:** Writing – review & editing,

Supervision, Investigation, Funding acquisition, Data curation, Conceptualization.

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## Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at [doi:10.1016/j.infbeh.2025.102130](https://doi.org/10.1016/j.infbeh.2025.102130).

## Data availability

Data will be made available on request.

## References

- Abney, D. H., Suanda, S. H., Smith, L. B., & Yu, C. (2020). What are the building blocks of parent–infant coordinated attention in free-flowing interaction? *Infancy*, 25(6), 871–887. <https://doi.org/10.1111/inf.12365>
- Anobile, G., Stievano, P., & Burr, D. C. (2013). Visual sustained attention and numerosity sensitivity correlate with math achievement in children. *Journal of Experimental Child Psychology*, 116(2), 380–391. <https://doi.org/10.1016/j.jecp.2013.06.006>
- Boraston, Z., & Blakemore, S.-J. (2007). The application of eye-tracking technology in the study of autism. *The Journal of Physiology*, 581(3), 893–898. <https://doi.org/10.1113/jphysiol.2007.133587>
- Borjon, J. I., Abney, D. H., Yu, C., & Smith, L. B. (2021). Head and eyes: Looking behavior in 12- to 24-month-old infants. *Journal of Vision*, 28(1).
- Boyer, T. W., Harding, S. M., & Bertenthal, B. I. (2020). The temporal dynamics of infants' joint attention: Effects of others' gaze cues and manual actions. *Cognition*, 197, Article 104151. <https://doi.org/10.1016/j.cognition.2019.104151>
- Bradshaw, J., Fu, X., Yurkovic-Harding, J., & Abney, D. (2023). Infant embodied attention in context: Feasibility of home-based head-mounted eye tracking in early infancy. *Developmental Cognitive Neuroscience*, 64, Article 101299. <https://doi.org/10.1016/j.dcn.2023.101299>
- Bradshaw, J., Shic, F., Holden, A. N., Horowitz, E. J., Barrett, A. C., German, T. C., & Vernon, T. W. (2019). The use of eye tracking as a biomarker of treatment outcome in a pilot randomized clinical trial for young children with autism. *Autism Research*, 12(5), 779–793. <https://doi.org/10.1002/aur.2093>
- Burling, J., & Yoshida, H. (2019). Visual constancies amidst changes in handled objects for 5- to 24-month-old infants. *Child Development*, 90(2), 452–461.
- Campbell, S. B., Leezenbaum, N. B., Mahoney, A. S., Day, T. N., & Schmidt, E. N. (2015). Social engagement with parents in 11-month-old siblings at high and low genetic risk for autism spectrum disorder. *Autism*, 19(8), 915–924. <https://doi.org/10.1177/1362361314555146>
- Carpenter, M., Nagell, K., & Tomasello, M. (1998). Social cognition, joint attention, and communicative competence from 9 to 15 months of age. *Monographs of the Society for Research in Child Development*, 63, 1–143.
- Choi, B., Nelson, C. A., Rowe, M. L., & Tager-Flusberg, H. (2020a). Reciprocal influences between parent input and child language skills in dyads involving high- and low-risk infants for autism spectrum disorder. *Autism Research*, 13(7), 1168–1183. <https://doi.org/10.1002/aur.2270>
- Choi, B., Shah, P., Rowe, M. L., Nelson, C. A., & Tager-Flusberg, H. (2020b). Gesture development, caregiver responsiveness, and language and diagnostic outcomes in infants at high and low risk for autism. *Journal of Autism and Developmental Disorders*, 50(7), 2556–2572. <https://doi.org/10.1007/s10803-019-03980-8>
- Clearfield, M. W., & Nelson, N. M. (2006). Sex differences in mothers' speech and play behavior with 6-, 9-, and 14-month-old infants. *Sex Roles*, 54(1–2), 127–137. <https://doi.org/10.1007/s11199-005-8874-1>
- Cleary, D. B., Maybery, M. T., Waddington, H., Macaskill, E., & Whitehouse, A. J. O. (2024). Investigating parental observations of early autism development in simplex and multiplex families. *Journal of Autism and Developmental Disorders*. <https://doi.org/10.1007/s10803-024-06262-0>
- Condy, E. E., Factor, R. S., Swain, D. M., Strege, M. V., & Scarpa, A. (2019). Maternal affect during a challenging mother–child interaction: The effects of broad autism phenotype and respiratory sinus arrhythmia reactivity in mothers of children with and without autism spectrum disorder. *Journal of Autism and Developmental Disorders*, 49(12), 4891–4900. <https://doi.org/10.1007/s10803-019-04198-4>
- Corkum, V., & Moore, C. (1998). The origins of joint visual attention in infants. *Developmental Psychology*, 34(1), 28–38. <https://doi.org/10.1037/0012-1649.34.1.28>
- Datavyu Team. (2014). *Datavyu: A video coding tool. [Computer software]*. Databrary Project.
- Dawson, G., Toth, K., Abbott, R., Osterling, J., Munson, J., Estes, A., & Liaw, J. (2004). Early social attention impairments in autism: Social orienting, joint attention, and attention to distress. *Developmental Psychology*, 40(2), 271–283. <https://doi.org/10.1037/0012-1649.40.2.271>
- De Giacomo, A., & Fombonne, E. (1998). Parental recognition of developmental abnormalities in autism. *European Child & Adolescent Psychiatry*, 7(3), 131–136. <https://doi.org/10.1007/s007870050058>
- Deák, G. O., Krasno, A. M., Jasso, H., & Triesch, J. (2018). What leads to shared attention? Maternal cues and infant responses during object play. *Infancy*, 23(1), 4–28. <https://doi.org/10.1111/inf.12204>
- Deák, G. O., Krasno, A. M., Triesch, J., Lewis, J., & Sepeta, L. (2014). Watch the hands: Infants can learn to follow gaze by seeing adults manipulate objects. *Developmental Science*, 17(2), 270–281. <https://doi.org/10.1111/desc.12122>
- Deák, G. O., Walden, T. A., Yale Kaiser, M., & Lewis, A. (2008). Driven from distraction: How infants respond to parents' attempts to elicit and re-direct their attention. *Infant Behavior and Development*, 31(1), 34–50. <https://doi.org/10.1016/j.infbeh.2007.06.004>
- Delucia, E. A., Semones, O., Stanton, K., & McDonnell, C. G. (2022). Advancing understanding of autism within families: Caregiver broader autism phenotype traits differentially relate to parenting behavior. *Journal of Child and Family Studies*, 31(3), 753–763. <https://doi.org/10.1007/s10826-021-02022-1>
- Derogatis, L. R., Lipman, R. S., Rickels, K., Uhlenhuth, E. H., & Covi, L. (1974). The Hopkins Symptom Checklist (HSCL). A measure of primary symptom dimensions. *Modern Problems of Pharmacopsychiatry*, 7, 79–110. <https://doi.org/10.1159/000395070>
- Falck-Ytter, T., Bolte, S., & Gredeback, G. (2013). Eye tracking in early autism research. *Journal of Neurodevelopmental Disorders*, 5(1), 28. <https://doi.org/10.1186/1866-1955-5-28>
- Fenson, L., Marchman, V. A., Thal, D. J., Dale, P. S., Reznick, J. S., & Bates, E. (2007). *MacArthur-Bates communicative development inventories: User's guide and technical manual* (2nd ed.). Baltimore, MD: Brookes.
- Flippin, M., & Watson, L. R. (2018). Parental broad autism phenotype and the language skills of children with autism spectrum disorder. *Journal of Autism and Developmental Disorders*, 48(6), 1895–1907. <https://doi.org/10.1007/s10803-017-3431-7>

- Franchak, J. M., Kretch, K. S., Soska, K. C., & Adolph, K. E. (2011). Head-mounted eye tracking: A new method to describe infant looking. *Child Development, 82*(6), 1738–1750. <https://doi.org/10.1111/j.1467-8624.2011.01670.x>
- Franchini, M., Hamodat, T., Armstrong, V. L., Sacrey, L.-A. R., Brian, J., Bryson, S. E., Garon, N., Roberts, W., Zwaigenbaum, L., & Smith, I. M. (2019). Infants at risk for autism spectrum disorder: Frequency, quality, and variety of joint attention behaviors. *Journal of Abnormal Child Psychology, 47*(5), 907–920. <https://doi.org/10.1007/s10802-018-0471-1>
- Frick, J. E., Colombo, J., & Saxon, T. F. (1999). Individual and developmental differences in disengagement of fixation in early infancy. *Child Development, 70*(3), 537–548. <https://doi.org/10.1111/1467-8624.00039>
- Galvan, M. J., Payne, B. K., Hannay, J., Georgeson, A. R., & Muscatell, K. A. (2023). What does the MacArthur scale of subjective social status measure? Separating economic circumstances and social status to predict health. *Annals of Behavioral Medicine: A Publication of the Society of Behavioral Medicine, 57*(11), 929–941. <https://doi.org/10.1093/abm/kaad054>
- Glascoe, F. P. (2003). Parents' evaluation of developmental status: How well do Parents' concerns identify children with behavioral and emotional problems? *Clinical Pediatrics, 42*(2), 133–138. <https://doi.org/10.1177/000992280304200206>
- Graham, K. E., Buryrn-Weitzel, J. C., Lahiff, N. J., Wilke, C., & Slocombe, K. E. (2021). Detecting joint attention events in mother-infant dyads: Sharing looks cannot be reliably identified by naïve third-party observers. *PLoS One, 16*(7), Article e0255241. <https://doi.org/10.1371/journal.pone.0255241>
- Hess, C. R., & Landa, R. J. (2012). Predictive and concurrent validity of parent concern about young children at risk for autism. *Journal of Autism and Developmental Disorders, 42*(4), 575–584. <https://doi.org/10.1007/s10803-011-1282-1>
- Hurley, R. S. E., Losh, M., Parlier, M., Reznick, J. S., & Piven, J. (2007). The broad autism phenotype questionnaire. *Journal of Autism and Developmental Disorders, 37*(9), 1679–1690. <https://doi.org/10.1007/s10803-006-0299-3>
- Jellema, T., Lorteije, J., Van Rijn, S., Wout, M., Haan, E., Engeland, H., & Kemner, C. (2009). Involuntary interpretation of social cues is compromised in autism spectrum disorders. *Autism Research, 2*, 192–204.
- Johansson, M., Marciszko, C., Gredebäck, G., Nyström, P., & Bohlin, G. (2015). Sustained attention in infancy as a longitudinal predictor of self-regulatory functions. *Infant Behavior and Development, 41*, 1–11. <https://doi.org/10.1016/j.infbeh.2015.07.001>
- Kannass, K. N., Oakes, L. M., & Shaddy, D. J. (2006). A longitudinal investigation of the development of attention and distractibility. *Journal of Cognition and Development, 7*(3), 381–409. [https://doi.org/10.1207/s15327647jcd0703\\_8](https://doi.org/10.1207/s15327647jcd0703_8)
- Kellerman, A. M., Schwichtenberg, A. J., Abu-Zhaya, R., Miller, M., Young, G. S., & Ozonoff, S. (2020). Dyadic synchrony and responsiveness in the first year: Associations with autism risk. *Autism Research, 13*(12), 2190–2201. <https://doi.org/10.1002/aur.2373>
- Koşulu, S., Küntay, A. C., Liszkowski, U., & Uzundag, B. A. (2021). Number and type of toys affect joint attention of mothers and infants. *Infant Behavior and Development, 64*, Article 101589. <https://doi.org/10.1016/j.infbeh.2021.101589>
- Kruper, J. C., & Uzgiris, I. C. (1987). Fathers' and mothers' speech to young infants. *Journal of Psycholinguistic Research, 16*(6), 597–614. <https://doi.org/10.1007/BF01067087>
- Liu, Q., Wang, Q., Li, X., Gong, X., Luo, X., Yin, T., Liu, J., & Yi, L. (2021). Social synchronization during joint attention in children with autism spectrum disorder. *Autism Research, 14*(10), 2120–2130. <https://doi.org/10.1002/aur.2553>
- Lord, C., Rutter, M., DiLavore, P. C., Risi, S., Gotham, K., & Bishop, S. (2012). *Autism diagnostic observation schedule* (2nd ed.). Western Psychological Services.
- MacNeill, L. A., Fu, Buss, K. A., & Pérez-Edgar, K. (2021). Do you see what I mean?: Using mobile eye tracking to capture parent-child dynamics in the context of anxiety risk | *Development and Psychopathology* | Cambridge Core. (<https://www.cambridge.org/core/lib.uh.edu/core/journals/development-and-psychopathology/article/doi-you-see-what-i-mean-using-mobile-eye-tracking-to-capture-parent-child-dynamics-in-the-context-of-anxiety-risk/32732C037360DCAE1879786204BC0C82>).
- Magrelli, S., Jermann, P., Basilio, N., Ansermet, F., Hentsch, F., Nadel, J., & Billard, A. (2013). Social orienting of children with autism to facial expressions and speech: A study with a wearable eye-tracker in naturalistic settings. *Frontiers in Psychology, 4*. <https://doi.org/10.3389/fpsyg.2013.00840>
- Martins, M. P., & Harris, S. L. (2006). Teaching children with autism to respond to joint attention initiations. *Child & Family Behavior Therapy, 28*(1), 51–68. [https://doi.org/10.1300/J019v28n01\\_04](https://doi.org/10.1300/J019v28n01_04)
- McDuffie, A., & Yoder, P. (2010). Types of parent verbal responsiveness that predict language in young children with autism spectrum disorder. *Journal of Speech, Language, and Hearing Research, 53*(4), 1026–1039. [https://doi.org/10.1044/1092-4388\(2009/09-0023\)](https://doi.org/10.1044/1092-4388(2009/09-0023))
- McMahon, C. R., Malesa, E. E., Yoder, P. J., & Stone, W. L. (2007). Parents of children with autism spectrum disorders have merited concerns about their later-born infants. (<https://doi.org/10.2511/rpsd.32.2.154>).
- Monlux, K., Pelaez, M., & Holth, P. (2019). Joint attention and social referencing in children with autism: A behavior-analytic approach. *European Journal of Behavior Analysis*. (<https://www.tandfonline.com/doi/abs/10.1080/15021149.2019.1644831>).
- Moore, V. C. Chris (1995). Development of joint visual attention in infants. In *Joint attention*. Psychology Press.
- Mundy, P. (2017). A review of joint attention and social-cognitive brain systems in typical development and autism spectrum disorder. *European Journal of Neuroscience, 47*(6), 497–514.
- Mundy, P. (2018). A review of joint attention and social-cognitive brain systems in typical development and autism spectrum disorder. *European Journal of Neuroscience, 47*(6), 497–514. <https://doi.org/10.1111/ejn.13720>
- Mundy, P., & Gomes, A. (1998). Individual differences in joint attention skill development in the second year. *Infant Behavior and Development, 21*(3), 469–482. [https://doi.org/10.1016/S0163-6383\(98\)90020-0](https://doi.org/10.1016/S0163-6383(98)90020-0)
- Mundy, P., & Jarrold, W. (2010). Infant joint attention, neural networks and social cognition. *Neural Networks, 23*(8), 985–997. <https://doi.org/10.1016/j.neunet.2010.08.009>
- Mundy, P., Sigman, M., & Kasari, C. (1990). A longitudinal study of joint attention and language development in autistic children. *Journal of Autism and Developmental Disorders, 20*(1), 115–128. <https://doi.org/10.1007/BF02206861>
- Murias, M., Major, S., Davlantis, K., Franz, L., Harris, A., Rardin, B., Sabatos-DeVito, M., & Dawson, G. (2018). Validation of eye-tracking measures of social attention as a potential biomarker for autism clinical trials. *Autism Research, 11*(1), 166–174. <https://doi.org/10.1002/aur.1894>
- Murza, K. A., Schwartz, J. B., Hahs-Vaughn, D. L., & Nye, C. (2016). Joint attention interventions for children with autism spectrum disorder: A systematic review and meta-analysis. *International Journal of Language & Communication Disorders, 51*(3), 236–251.
- Navab, A., Gillespie-Lynch, K., Johnson, S. P., Sigman, M., & Hutman, T. (2011). Eye-tracking as a measure of responsiveness to joint attention in infants at risk for autism. *The Official Journal of the International Congress of Infant Studies, 17*(4), 416–431.
- Nyström, P., Thorup, E., Bölte, S., & Falck-Ytter, T. (2019). Joint attention in infancy and the emergence of autism. *Biological Psychiatry, 86*(8), 631–638. <https://doi.org/10.1016/j.biopsych.2019.05.006>
- O'Brien, M., & Nagle, K. J. (1987). Parents' speech to toddlers: The effect of play context. *Journal of Child Language, 14*(2), 269–279. <https://doi.org/10.1017/S0305000900012927>
- Ozonoff, S., Young, G. S., Steinfeld, M. B., Hill, M. M., Cook, I., Hutman, T., Macari, S., Rogers, S. J., & Sigman, M. (2009). How early do parent concerns predict later autism diagnosis? *Journal of Developmental & Behavioral Pediatrics, 30*(5), 367. <https://doi.org/10.1097/DBP.0b013e3181ba0fcf>
- Pereira, A. F., Smith, L. B., & Yu, C. (2014). A bottom-up view of toddler word learning. *Psychonomic Bulletin Review, 21*(1), 178–185. <https://doi.org/10.3758/s13423-013-0466-4>
- Perkovich, E., Laakman, A., Mire, S., & Yoshida, H. (2024). Conducting head-mounted eye-tracking research with young children with autism and children with increased likelihood of later autism diagnosis. *Journal of Neurodevelopmental Disorders, 16*(1), 7. <https://doi.org/10.1186/s11689-024-09524-1>
- Perkovich, E., Sun, L., Mire, S., Laakman, A., Sakhuja, U., & Yoshida, H. (2022). What children with and without ASD see: Similar visual experiences with different pathways through parental attention strategies. *Autism & Developmental Language Impairments, 7*, Article 23969415221137293. <https://doi.org/10.1177/23969415221137293>
- Perkovich, E., & Yoshida, H. (2024a). How parents impact the joint attention-vocabulary bond for children with autism. In *2024 IEEE international conference on development and learning (ICDL)* (pp. 1–6). <https://doi.org/10.1109/ICDL61372.2024.10644652>

- Perkovich, E., & Yoshida, H. (2024b). Infant sex effect on naturally occurring attention behaviors during interactive object play. In *Proceedings of the IEEE international conference on development and learning IEEE international conference on development and learning*.
- Perkovich, E., & Yoshida, H. (2025). Parental broad autism phenotype traits and their influence on early social interaction and attention. In *Proceedings of the annual meeting of the cognitive science society*.
- Perryman, T. Y., Carter, A. S., Messinger, D. S., Stone, W. L., Ivasnescu, A. E., & Yoder, P. J. (2013). Brief report: Parental child-directed speech as a predictor of receptive language in children with autism symptomatology. *Journal of Autism and Developmental Disorders*, 43(8), 1983–1987. <https://doi.org/10.1007/s10803-012-1725-3>
- Pierce, K., Gazestani, V. H., Bacon, E., Barnes, C. C., Cha, D., Nalabolu, S. C., & E. (2019). Evaluation of the diagnostic stability of the early autism spectrum disorder phenotype in the general population starting at 12 months. *JAMA Pediatrics*, 173(6), 578–587. <https://doi.org/10.1001/jamapediatrics.2019.0624>
- Pijl, M. K. J., Bontinck, C., Rommelse, N. N. J., Begum Ali, J., Cauvet, E., Niedzwiecka, A., Falck-Ytter, T., Jones, E. J. H., Van den Boomen, C., Bölte, S., Johnson, M. H., Charman, T., Warreyn, P., Roeyers, H., Buitelaar, J. K., & Oosterling, I. J. (2021). Parent-child interaction during the first year of life in infants at elevated likelihood of autism spectrum disorder. *Infant Behavior and Development*, 62, Article 101521. <https://doi.org/10.1016/j.infbeh.2020.101521>
- Presmanes, A. G., Walden, T. A., Stone, W. L., & Yoder, P. J. (2007). Effects of different attentional cues on responding to joint attention in younger siblings of children with autism spectrum disorders. *Journal of Autism and Developmental Disorders*, 37(1), 133–144. <https://doi.org/10.1007/s10803-006-0338-0>
- Regehr, K., & Feldman, M. (2009). Parent-selected interventions for infants at-risk for autism spectrum disorders and their affected siblings. *Behavioral Interventions*, 24(4), 237–248. <https://doi.org/10.1002/bin.291>
- Robins, D. L., Casagrande, K., Barton, M., Chen, C.-M. A., Dumont-Mathieu, T., & Fein, D. (2014). Validation of the modified checklist for autism in toddlers, revised with follow-up (M-CHAT-R/F). *Pediatrics*, 133(1), 37–45. <https://doi.org/10.1542/peds.2013-1813>
- Sasson, N. J., Lam, K. S. L., Childress, D., Parlier, M., Daniels, J. L., & Piven, J. (2013). The broad autism phenotype questionnaire: Prevalence and diagnostic classification. *Autism Research: Official Journal of the International Society for Autism Research*, 6(2), 134–143. <https://doi.org/10.1002/aur.1272>
- Schroer, S. E., Peters, R. E., & Yu, C. (2024). Consistency and variability in multimodal parent-child social interaction: An at-home study using head-mounted eye trackers. *Developmental Psychology*, 60(8), 1432–1446. <https://doi.org/10.1037/dev0001756>
- Siller, M., & Sigman, M. (2002). The behaviors of parents of children with autism predict the subsequent development of their children's communication. *Journal of Autism and Developmental Disorders*, 32(2), 77–89. <https://doi.org/10.1023/A:1014884404276>
- Siller, M., & Sigman, M. (2008). Modeling longitudinal change in the language abilities of children with autism: Parent behaviors and child characteristics as predictors of change. *Developmental Psychology*, 44(6), 1691–1704. <https://doi.org/10.1037/a0013771>
- Slonims, V., & McConachie, H. (2006). Analysis of mother-infant interaction in infants with Down syndrome and typically developing infants. *American Journal on Mental Retardation*, 111(4), 273–289. [https://doi.org/10.1352/0895-8017\(2006\)111\[273:AOMIII\]2.0.CO;2](https://doi.org/10.1352/0895-8017(2006)111[273:AOMIII]2.0.CO;2)
- Smith, L. M., Yurkovic-Harding, J., & Carver, L. J. (2023). Multimodal pathways to joint attention in infants with a familial history of autism. *Developmental Cognitive Neuroscience*, 64, Article 101325. <https://doi.org/10.1016/j.dcn.2023.101325>
- Smith, Yu, C., & Pereira, A. F. (2011). Not your mother's view: The dynamics of toddler visual experience. *Developmental Science*, 14(1), 9–17. <https://doi.org/10.1111/j.1467-7687.2009.00947.x>
- Smith, Yu, C., Yoshida, H., & Fausey, C. M. (2015). Contributions of head-mounted cameras to studying the visual environments of infants and young children. *Journal of Cognition and Development: Official Journal of the Cognitive Development Society*, 16(3), 407–419. <https://doi.org/10.1080/15248372.2014.933430>
- Srinivasan, S., & Bhat, A. (2020). Differences in caregiver behaviors of infants at-risk for autism and typically developing infants from 9 to 15 months of age. *Infant Behavior and Development*, 59, Article 101445. <https://doi.org/10.1016/j.infbeh.2020.101445>
- Steiner, A. M., Gengoux, G. W., Smith, A., & Chawarska, K. (2018). Parent-child interaction synchrony for infants at-risk for autism spectrum disorder. *Journal of Autism and Developmental Disorders*, 48(10), 3562–3572. <https://doi.org/10.1007/s10803-018-3624-8>
- Suarez-Rivera, C., Smith, L. B., & Yu, C. (2019). Multimodal parent behaviors within joint attention support sustained attention in infants. *Developmental Psychology*, 55(1), 96–109. <https://doi.org/10.1037/dev0000628>
- Sun, L., Francis, D. J., Nagai, Y., & Yoshida, H. (2024). Early development of saliency-driven attention through object manipulation. *Acta Psychologica*, 243, Article 104124. <https://doi.org/10.1016/j.actpsy.2024.104124>
- Sun, L., Gidh, N., & Yoshida, H. (2023). Why are nouns learned earlier than verbs? Infant's multimodal experiences during object play. In *2023 IEEE international conference on development and learning (ICDL)* (pp. 443–448). <https://doi.org/10.1109/ICDL55364.2023.10364493>
- Sun, L., Griep, C. D., & Yoshida, H. (2022). Shared multimodal input through social coordination: Infants with monolingual and bilingual learning experiences. *Frontiers in Psychology*, 1608.
- Sun, L., & Yoshida, H. (2022). Why the parent's gaze is so powerful in organizing the infant's gaze: The relationship between parental referential cues and infant object looking. *Infancy*, 27(4), 780–808. <https://doi.org/10.1111/inf.12475>
- Swinkels, S. H. N., Dietz, C., van Daalen, E., Kerkhof, I. H. G. M., van Engeland, H., & Buitelaar, J. K. (2006). Screening for autistic spectrum in children aged 14–15 months. I: The development of the early screening of autistic traits questionnaire (ESAT). *Journal of Autism and Developmental Disorders*, 36(6), 723–732. <https://doi.org/10.1007/s10803-006-0115-0>
- Tamis-LeMonda, C., Kuchirko, Y., & Song, L. (2014). Why is infant language learning facilitated by parental responsiveness? *Current Directions in Psychological Science*, 23, 121–126. <https://doi.org/10.1177/0963721414522813>
- Taylor, B. A., & Hoch, H. (2008). Teaching children with autism to respond to and initiate bids for joint attention. *Journal of Applied Behavior Analysis*, 41(3), 377–391. <https://doi.org/10.1901/jaba.2008.41-377>
- Thorup, E., Nyström, P., Gredebäck, G., Bölte, S., Falck-Ytter, T., & The EASE Team. (2016). Altered gaze following during live interaction in infants at risk for autism: An eye tracking study. *Molecular Autism*, 7(1), 12. <https://doi.org/10.1186/s13229-016-0069-9>
- Tomasello, M. (1995). Joint attention as social cognition. In *Joint attention: Its origins and role in development* (pp. 103–130). Lawrence Erlbaum Associates, Inc.
- Tomasello, M., & Farrar, M. J. (1986). Joint attention and early language. *Child Development*, 57(6), 1454. <https://doi.org/10.2307/1130423>
- Wan, M. W., Green, J., Elsabbagh, M., Johnson, M., Charman, T., & Plummer, F. (2012). Parent-infant interaction in infant siblings at risk of autism. *Research in Developmental Disabilities*, 33(3), 924–932. <https://doi.org/10.1016/j.ridd.2011.12.011>
- Wan, M. W., Green, J., Elsabbagh, M., Johnson, M., Charman, T., Plummer, F., & BASIS Team. (2013). Quality of interaction with at-risk infants and caregiver at 12–15 months is associated with 3-year autism outcome. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, 54(7), 763–771. <https://doi.org/10.1111/jcpp.12032>
- Weisberg, H. R., & Jones, E. A. (2019). Individualizing intervention to teach joint attention, requesting, and social referencing to children with autism. *Behavior Analysis in Practice*, 12(1), 105–123. <https://doi.org/10.1007/s40617-018-0265-5>
- Yirmiya, N., Gamliel, I., Pilowsky, T., Feldman, R., Baron-Cohen, S., & Sigman, M. (2006). The development of siblings of children with autism at 4 and 14 months: Social engagement, communication, and cognition. *Journal of Child Psychology and Psychiatry, and Allied Disciplines*, 47(5), 511–523. <https://doi.org/10.1111/j.1469-7610.2005.01528.x>
- Yoshida, H., Cirino, P., Mire, S., & Burling, J. (2019). Parents' gesture adaptations to children with autism spectrum disorders. *Journal of Child Language*, 1–20. <https://doi.org/10.1017/S0305000919000497>
- Yoshida, H., & Smith, L. B. (2008). What's in view for toddlers? Using a head camera to study visual experience. *Infancy: The Official Journal of the International Society on Infant Studies*, 13(3), 229–248. <https://doi.org/10.1080/15250000802004437>
- Yu, C., & Smith, L. B. (2013). Joint attention without gaze following: Human infants and their parents coordinate visual attention to objects through eye-hand coordination. *PLoS One*, 8(11), Article e79659. <https://doi.org/10.1371/journal.pone.0079659>
- Yu, C., & Smith, L. B. (2015). Linking joint attention with hand-eye coordination – A sensorimotor approach to understanding Child-Parent social interaction. In *CogSci ... annual conference of the cognitive science society, 2015* pp. 2763–2768). U.S.: Cognitive Science Society (Conference).
- Yu, C., & Smith, L. B. (2016). The social origins of sustained attention in one-year-old human infants. *Current Biology: CB*, 26(9), 1235–1240. <https://doi.org/10.1016/j.cub.2016.03.026>

- Yu, C., & Smith, L. B. (2017a). Hand-eye coordination predicts joint attention. *Child Development*, *88*(6), 2060–2078. <https://doi.org/10.1111/cdev.12730>
- Yu, C., & Smith, L. B. (2017b). Multiple sensory-motor pathways lead to coordinated visual attention. *Cognitive Science*, *41*(1(1)), 5–31. <https://doi.org/10.1111/cogs.12366>
- Yu, C., Suanda, S. H., & Smith, L. B. (2019). Infant sustained attention but not joint attention to objects at 9 months predicts vocabulary at 12 and 15 months. *Developmental Science*, *22*(1), Article e12735. <https://doi.org/10.1111/desc.12735>
- Yurkovic, J. R., Lisandrelli, G., Shaffer, R. C., Dominick, K. C., Pedapati, E. V., Erickson, C. A., Kennedy, D. P., & Yu, C. (2020). Examining sustained attention in child-parent interaction: A comparative study of typically developing children and children with autism spectrum disorder. *Proceedings of the Annual Meeting of the Cognitive Science Society*, *42*. (<https://escholarship.org/uc/item/2z51x9f8>).
- Yurkovic, J. R., Lisandrelli, G., Shaffer, R. C., Dominick, K. C., Pedapati, E. V., Erickson, C. A., Kennedy, D. P., & Yu, C. (2021). Using head-mounted eye tracking to examine visual and manual exploration during naturalistic toy play in children with and without autism spectrum disorder. *Scientific Reports*, *11*(1), 3578. <https://doi.org/10.1038/s41598-021-81102-0>
- Yurkovic-Harding, J., Lisandrelli, G., Shaffer, R., Dominick, K., Pedapati, E., Erickson, C., Yu, C., & Kennedy, D. (2022). Children with ASD establish joint attention during free-flowing toy play without face looks. *Current Biology*, *32*. <https://doi.org/10.1016/j.cub.2022.04.044>
- Zukow-Goldring, P. (1996). Sensitive caregiving fosters the comprehension of speech: When gestures speak louder than words. *Early Development and Parenting*, *5*(4), 195–211. [https://doi.org/10.1002/\(SICI\)1099-0917\(199612\)5:4<195::AID-EDP133>3.0.CO;2-H](https://doi.org/10.1002/(SICI)1099-0917(199612)5:4<195::AID-EDP133>3.0.CO;2-H)