THE RELATIONSHIP BETWEEN DISTRACTIBILITY AND JOINT ATTENTION IN TODDLERS

by

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(Under the Direction of Janet Frick)

ABSTRACT

Joint attention (JA) is a widely studied developmental phenomenon and is a key component of toddler social development. The relation JA has with social outcomes is well-studied, but less is known about how it is shaped by the developmental emergence of core attentional properties. Distractibility, a capacity that is linked to attentional processes that are also important to JA, could be a source of individual differences in JA. Toddlers in the 16-34 month age range (N = 98) were recruited and participated in a free play task. An inverse relation between distractibility and RJA was found in our 24 month age group. A within-subject exploratory analysis also showed strong differences in IJA depending on the presence or absence of an active social partner during the session for our 24-, 31-, and 34-month-old groups. Potential future directions are discussed.

INDEX WORDS: Development, Distractibility, Joint attention, Social, Toddlers

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TABLE OF CONTENTS

APPENDICES

LIST OF TABLES

Page

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

Joint attention (JA) is a widely studied developmental phenomenon and is a key component of toddler social development. The relation JA has with social outcomes is well-studied, but less is known about how it is shaped by the developmental emergence of core attentional properties. Distractibility, a capacity that is linked to attentional processes that are also important to JA, could be a source of individual differences in JA. The goal of the present study was to examine the links between distractibility in a free play setting and JA. Our results add to our understanding of JA in typically developing toddlers.

What is JA?

Joint attention is the sharing of attention among persons towards a common referent through the use of gesture and eye gaze (Mundy & Newell, 2007). A child looking at a neighbor's dog pointed out by their mother, or a child and teacher looking together at a book are both examples of joint attention. The importance of JA is recognized in early language development (Tomasello & Todd, 1983; Tomasello & Farrar, 1986) and early social development more broadly (Brooks & Meltzoff, 2015; Sodian & Kristian-Antonow, 2015); the ability to share attention on a common referent with a social partner is an essential building block of early communication and social engagement.

Joint attention is frequently subdivided into two types: initiating joint attention (IJA) and responding to joint attention (RJA) (Mundy & Newell, 2007). While the initiating and responding can be from the perspective of either social partner regardless of age, the majority of developmental studies of JA are interested in the child's initiating and responding behaviors, and our focus will be on the child's IJA and RJA as well. A child spontaneously pointing towards an object in the environment or showing off a toy to an adult are examples of IJA. A child following the direction indicated by an adult's pointing finger with their eyes or picking up an object an adult indicates would be defined as RJA. Both forms of JA are thought to be served by different cognitive systems, with symbolic thought important to RJA and social motivation important to IJA (Mundy & Gomes, 1998). As we will discuss, we do see differences in the developmental timeline of IJA and RJA as might be expected given these underlying differences. While there are different brain areas recruited for IJA and RJA, some of the overlapping regions are shared with the network related to mentalizing, suggesting that taking the perspective of others in social situations shares important processes with both IJA and RJA (Mundy, 2018).

Definitions of these joint behaviors sometimes differentiate behavioral requests from joint attention behaviors (e.g., Mundy et al., 2007). While joint attention behaviors are thought to primarily serve a social function, borne out of a desire for the two partners to engage in a social interaction, behavioral requests are instrumental in nature; one of the partners requesting help with a task from the other. We will concern ourselves with the better-studied IJA and RJA in the present study.

We also wanted to acknowledge some disagreement in the literature over how best to conceptualize JA. Some argue that much of the JA literature uses operational definitions that are inadequate to capture the psychological states of JA, and would argue good objective operational definitions are not possible (see Bard et al., 2021 for a discussion). For the purposes of the current study, however, we will be following traditional JA definitions and provide our operational definition in our procedure.

Development of JA

Joint attention development begins with the development of intersubjectivity, which can be defined as the ability to recognize the subjective states of other persons (Trevarthen, 1979). Intersubjectivity involves the basic coordination of attention among social partners, in contrast to theory of mind, which involves an understanding of the unobservable mental states and beliefs of others (Frith & Frith, 2005). Primary intersubjectivity usually develops by 2-3 months of age, as infants start showing coordination of their attention and behavior with the vocalizations and gestures of a dyadic partner (Bateson, 1975; Fogel & Hannan, 1985; Tronick et al., 1980). By the second half of the first year, infants develop secondary intersubjectivity, or an ability to coordinate attention between the dyadic partner and an object in the environment. The most commonly studied form of secondary intersubjectivity is JA. What became known as joint attention began to receive attention after Scaife and Bruner’s (1975) observation that infants in their first year of life could follow the gaze of others, challenging Piagetian conceptions of infant egocentrism (Piaget, 1930).

Although the early building blocks of JA begin to appear by 3 months (Mundy & Newell, 2007), JA is not considered fully formed until closer to 18 months of age. We see recognizable RJA emerging at least by 6 months of age (Morales et al., 2006) and IJA by 9 months of age (Brooks & Meltzoff, 2005). Several studies have examined the emergence of various JA foundational skills, as well as early limitations that preclude a full JA interaction. For example, prior to 10 months of age, infants may not reliably follow the gaze of others (Moore & Corkum, 1998). By 12 months of age, infants learn how to extrapolate where a social partner has their gaze pointed in the environment; between 12 and 18 months, they develop the ability to form a mental representation of objects outside of their personal visual field (Butterworth & Jarrett, 1991). For typically developing infants, IJA has a complicated relationship with age between 12 and 18 months with no simple linear change (Sheinkopf et al., 2004; Mundy et al., 2007), though there is a linear increase between 14 and 24 months (Landa et al. (2013) and evidence of a small linear increase in IJA across 12 to 30 months (Adamson et al., 2021). Premature birth may lead to deficits in RJA at 12-18 months, while IJA may be comparable to children with full term births (Mateus et al., 2020).

Correlates and Implications of JA

Having established how JA is typically defined and how it is thought to develop, next, we explore how JA relates to other variables. We know of some predictors of JA at young ages. In one study, maternal behavior during a toy-play activity at 6 months, specifically their sensitivity to their child and their use of instructional play techniques, predicted some variation in IJA behavior at 9 months, while maternal demographics, cognitive variables, and psychiatric factors did not (Gaffan et al., 2010). Attachment style can also be a predictor; one study found that 15-month-olds, though not 8-month-olds, with insecure-avoidant attachment had increased IJA (Meins et al., 2011). A study of 9- and 12-month-olds found that caregiver scaffolding and infant temperament were correlated with IJA, though not RJA (Vaughan et al., 2003). Some research finds that JA in toddlers mediates the relation between attuned caregiving in infancy and executive function in early childhood (Brandes-Aitken et al., 2020).

The language development literature has held great interest in the role joint attention plays. In particular, the literature suggests that RJA is valuable in predicting language outcomes;

Morales et al. (2000) found that RJA up through 18 months predicted later language development at 30 months. Fewer studies support the role of IJA in language development, though Mundy et al. (2003) found both IJA and RJA at 14 months were predictors of parent-reported language development at 24 months. There is also evidence that JA may be crucial to language interventions. In a study of children around 48 months old (chronological age) with autism, children who showed more successful RJA showed more gains in “language age” following a language intervention (Bono et al., 2003), though some research suggests it is not joint attention itself, but the sustained attention that joint attention episodes promote, that aids language development (e.g., Yu et al., 2019).

The importance of JA to early social and communicative development has led to interest in the topic for understanding populations with deficits in these areas. Indeed, JA has been studied extensively among populations diagnosed with, or at risk for, autism spectrum disorders (ASD). Studies of children with ASD generally find that JA skills are positively correlated with social functioning (Dawson et al., 2004; Charman, 2003; Toth et al., 2006; Bal et al., 2020). Interventions designed to address the social deficits observed in children with ASD, such as JASPER (Joint Attention, Symbolic Play, Engagement, and Regulation; Kasari et al., 2006), often make JA skills a key target.

Even in ASD, however, the operational definition of JA matters. Although people with ASD demonstrate lower rates of the typical gaze-following behaviors sometimes considered important to JA definitions (Phillips et al., 1992; Dalton et al., 2005; Pelphrey et al., 2002), when relaxing the definition of JA to include any shared bouts of attention to a third object, toddlers with ASD may not show any differences from TD (Yurkovic-Harding et al., 2022). While JA deficits are associated with ASD, this does not hold for other developmental disorders such as

Down's Syndrome (Hahn et al., 2018), suggesting JA skills do not necessarily suffer from global mental impairment. How JA develops also likely depends on the affordances of the partners involved; a study of toddler-parent dyads found that dyads where both partners were deaf showed gaze patterns that differed from TD dyads during JA (Lieberman et al., 2014). Although there are some differences in the ways non-TD populations engage with social partners, social interactions remain important targets for study.

In sum, joint attention holds considerable importance in understanding social development. Early interactions with caregivers show a relation to later joint attention, and joint attention in turn informs our understanding of disorders such as autism.

Development of Distractibility

Joint attention requires the child to sustain a focus of attention as well as to manage competing sources of stimulation. Next we discuss how this capacity develops in infants and toddlers and how they deal with distractions. Distractibility refers to a person's susceptibility to losing focus on the task at hand (Kannass et al., 2006). Successful joint attention requires not only an understanding of social partners, but also the ability to direct and shift attentional focus. Further, successful joint attention requires the capacity to focus on the object of joint attention while avoiding attentional capture from distractors.

There are three theorized networks in the brain that control attentional processes: orienting, alerting, and detecting/executive control (Posner & Petersen, 1990; Petersen & Posner, 2012). The orienting network governs the processes involved in shifting attention to exogenous stimuli. The alerting network regulates arousal and vigilance, preparing a person to respond to stimuli. The detecting network, which is considered a component of a larger executive control network in more recent literature (Petersen & Posner, 2012), is related to the conscious awareness exhibited when focused on a stimulus. Many of these attentional systems are operational, at least at a basic level of efficiency, by 6 months of age (see Colombo, 2001 for review). However, executive control takes more time to develop. Sustained attention, or ability to maintain attention to a target, continues to develop well into the third year (Ruff & Lawson, 1990). Selective attention, or ability to tune out distractions, seems to reach capacity similar to adults by at least 6 years of age (Rueda et al., 2004). In short, the requisite cognitive attentional skills for joint attention, such as sustained and selective attention, are in place within the first year, but there are likely still quantitative gains in these systems made over the next few years.

Similar to the other executive control processes, distractibility shows a protracted development. Distractibility becomes an important attentional capacity with the emergence of endogenous attentional control in the second half of the first year of life; in infants under 6 months of age, attention is primarily exogenously-driven, with the infant having limited volitional control. Up through 5 years of age, distractibility research generally finds little age-related change (Oakes et al., 2004; Richards & Turner, 2001; Anderson et al., 1987; though see Ruff & Capozzoli, 2003). Perhaps the aspect of distractibility that does show the most change over early childhood is the influence of distractor characteristics. In one study of infants watching a movie, 6- to 24-month-olds showed no age effects in distractibility when presented with visual distractors on the periphery; however, they did find that children were slower to orient towards distractors the longer they sustained attention to the target audio-visual stimulus (Richards & Turner, 2001). Kannass and colleagues (2006) used an audiovisual distractor and found stability in individual distractibility between 7- and 9-months of age, as well as 9- and 31-months of age. On the other hand, Ruff and Capozzoli (2003) did find that distractibility decreased with age across 10-, 26-, and 42-month-olds; interestingly, the modality of distraction that was most salient also changed with age: while younger children were more distracted by audio-visual distractions, the oldest children were most distracted by visual-only distractors. Another study of distractibility found that sixth graders made fewer errors in the presence of loud auditory distractors in an age-appropriate visual discrimination task, while preschoolers made fewer errors when no distractors were present (Higgins & Turnure, 1984). In summary, research is mixed on age effects on distractibility, though there is consistent evidence that the modality of the distraction matters.

Individual differences in distractibility have some known correlates, including various physiological measures (Geva et al., 2016; Holmboe et al., 2012; Colombo et al., 2004); correlates with social behavior are less well-studied. In a study of 3-year-olds' adjustment to nursery school, the children's heart period, vagal tone, and parent-reported temperament were collected (Fox & Field, 1989). Parent-reported low distractibility was correlated with more solitary play in the first two weeks, but also a greater decrease in solitary play and increase in interactive play over the first six weeks of preschool (Fox & Field, 1989). Outside of this study, however, little research currently exists linking distractibility and social behavior.

Purpose of the Current Study: Relation Between Distractibility and JA

So far, we have discussed the development of JA, and the development of distractibility as a key component of early attention. The executive control network important in distractibility development also helps tune out irrelevant exogenous stimuli during joint attention, but there are gaps in the research connecting these two capacities.

Existing research suggests that toddlers who show more advanced executive function engage in more JA, though results are mixed. Gago Galvagno and colleagues (2019) recruited preschool-age children to complete a series of executive function tasks and the Early Social Communication Scales (ESCS) (Mundy et al., 2003), a popular laboratory measure for JA (e.g., Vaughan et al., 2007; Dawson et al., 2004; Salo et al., 2018). To compare executive function development across the sample, the number of tasks the child successfully passed was correlated with other variables of interest. Researchers found positive correlations between IJA and RJA and the number of executive function tasks successfully completed by preschool-age children; that is, children who initiated more bids of joint attention, and responded appropriately to adult's bids more frequently, tended to succeed in a greater number of executive function tasks.

Using a similar procedure, Miller and Marcovitch (2015) found that infants who engaged in greater proportions of advanced IJA behaviors, such as pointing, compared to basic IJA behaviors, such as eye gaze, had more executive function successes. However, Miller and Marcovitch did not find general correlations between JA and executive function, though their participants were younger (14 and 18 months old), compared to Gago Galvagno and colleagues' participants (who were 18-24 months of age). A follow-up study by Gago Galvagno and colleagues (2021) with 18-36 month-olds only found a relationship between RJA and executive function task successes, with IJA being uncorrelated with executive function performance. Taken together, these studies suggest a relationship between JA and executive function, though findings are inconsistent.

These laboratory (Miller & Marcovitch, 2015) and low-distraction environment (L.G. Gago Galvagno, personal communication, October 12, 2021) studies of executive function only give a partial picture of distractibility's involvement in JA. Most "real world" JA episodes occur in naturalistic settings that will include competing exogenous stimuli; while we might expect young children who are more skilled at managing distractors to be better able to engage in JA, experimental testing of this idea has been lacking. Doing so would require presenting salient distractors alongside the free-play tasks in which JA was measured.

The present study investigated this question in a sample of typically developing children. The goal was to investigate the relation between distractibility and joint attention behavior. The largest difference of this study compared to most existing joint attention studies is that it has the control of a laboratory-based social interaction between an experimenter and a child, combined with the addition of a TV occasionally playing video clips to distract the child and simulate the busy perceptual landscape of a child's home.

As such, the present study had three major aims. First, we wanted to ensure we replicated the age-related trends in the literature. Specifically, we expected an increase in IJA, at least between the youngest children in our study (16 months old) and the older children (24, 31, and 34 months old). In contrast, we expected a lack of change in distractibility across our sample. Second, we wanted to extend the literature by investigating the relation between JA and distractibility. Based on existing research, we hypothesized that there would be a negative correlation between distractibility and both IJA and RJA. Third, we wanted to investigate a more exploratory question that could lend itself well towards the data: how does IJA change according to the presence or absence of an active social partner?

Aim 1: In line with the existing literature, we expect to find age-related increases in IJA, but no age-related change for distractibility in our sample (age range: 16-34 months).

Aim 2: We hypothesize an inverse relationship between JA and distractibility within age groups.

Aim 3: We plan to explore how social feedback from the experimenter affects IJA.

CHAPTER 2

METHODS

Participants

For the groups examined for the present study, a total of 131 toddlers were recruited from the greater Baltimore area and tested at the University of Maryland. Of these, some were dropped due to a combination of tech issues, errors in the procedure, and/or child fussiness that led to either unusable data or attrition prior to completing study procedures (N = 33). This left a sample of 98 toddlers to analyze. The sample was predominantly white and came from from well-educated families. A fuller breakdown of demographics are provided in Table 1.

Procedure

Toddlers engaged in a laboratory-based free-play task as part of a larger collaborative study with colleagues at the University of Maryland. Data was collected at Maryland, and all of the attention coding was done at UGA. IRB approval for data collection and coding procedures was obtained at both the University of Maryland and the University of Georgia. The attention task consisted of four trials scripted to run two minutes each. Toddlers sat in their caregiver's lap across from an experimenter at a table. Caregivers were instructed to look down and avoid interacting with their child, outside of adjustments and reassurance as needed. Three cameras in the room recorded the session from different angles. In each trial, a new set of toys was presented to the child. Toys included age-appropriate play items such as a Fisher Price bus with passengers, a Fisher Price plane with passengers, colored tiles, and magnetic connecting rods. The trials followed a two (non-social vs. social) by two (no distractors vs. distractors) factorial design, and progressed in a fixed order for all participants (Table 2). In non-social trials, the experimenter remained quiet and appeared busy with paperwork. In social trials, the experimenter made social bids towards the child at scripted intervals. In no distractor trials a TV positioned 90 degrees to the left of the child remained off. In distractor trials the TV intermittently played 7-second clips from Sesame Street episodes at multiple times throughout the trial.

The children's participation was coded offline using the open source video coding program Datavyu (Datavyu Team, 2014). Coders were undergraduate assistants trained on coding procedures with videos from the sample before they began coding videos that would be used for data analysis. No coder was responsible for doing the full coding of a video on which they had previously been trained. Figure 1 shows an example of what coders saw.

The videos were coded for child behaviors and eye movements during the task; primarily, where was the child's attention directed in their environment, whether it be the toys in front of them, the TV distractor, or an adult in the room. See Appendix A for an operational definition of the codes that were used. Not all of the codes listed are relevant to the present project, and not all codes were used in every condition.

Operational definitions for joint attention are similar to existing definitions in the literature (e.g., Mundy et al., 2003). Initiating joint attention (IJA) was operationally defined as the child initiating an attempt to direct an adult's attention towards a third entity in the environment during any condition. The child needed to glance in the direction of an adult while making some clear indication of trying to direct the adult's attention towards a third object. Pointing, showing, and alternating eye gaze were valid behaviors to be counted as IJA. In contrast to the ESCS, the child's parent was a valid social partner for the sake of IJA behaviors. IJA was analyzed as a count of episodes that occurred. Inter-rater reliability for IJA count was good, ICC = .89. Responding to joint attention (RJA) was counted when the child acknowledged a scripted bid from the experimenter in social conditions. Looking at either the toy the experimenter indicated or the experimenter themself during their bid was necessary to be considered successful RJA. RJA was analyzed as a proportion of appropriate responses, where a child who responded to all experimenter bids would have a score of 1. Inter-rater agreement for RJA was high, with 92.1% agreement.

Distraction was defined as time spent looking towards the TV while it was playing a clip. Our definition was similar to other studies that have used TV distractors in toddlers (e.g., Kannass et al., 2010; Schmidt et al., 2008). Continuing to look towards the TV after the clip was terminated was considered part of the same longer look, though initiating a look while the TV was blank was not counted as distraction. Distraction was analyzed as a proportion of the condition that the child spent distracted. Inter-rater reliability was good, ICC = .96. To ensure full independence of our IJA and distractibility data, analyses used distraction from one distractor condition and compared it to IJA from the other distractor condition.

Table 1. Demographics of the larger sample.

Characteristic	%
Sex	
Male	52.7
Female	47.3
Race / Ethnicity	
White	69.4
Black	6.9
Asian	1.5
Multiracial	12.2
Latinx	3.8
Not Specified	4.6
Mother's Education	
Less than college degree	2.3
College degree	31.8
Post-graduate degree	62.0
Not Specified	3.9
Father/Parent 2's Education	
Less than college degree	9.3
College degree	26.4
Post-graduate degree	59.7
Not Specified	4.7

Table 2. Breakdown of experimental conditions by order of presentation.

Condition	**Distractor?** (A TV plays different Sesame Street clips multiple times throughout the condition)	**Social?** (The experimenter initiates social bids with the child concerning the toys)
A	No	No
B	Yes	No
C	No	Yes
D	Yes	Yes

Figure 1. Example video frame of a participant during the free play task.

CHAPTER 3

RESULTS

Basic descriptive statistics are presented in Table 3. One participant had missing data for one condition and was excluded from relevant analyses.

Developmental Changes in IJA and Distractibility

Our first aim was a replication of the age-related patterns in IJA and distractibility observed in the literature. Figures 2 and 3 present average IJA and distractibility by age group. A one-factor (age group) MANOVA of session-wide IJA and distractibility was significant, $F(3,184) = 3.72$, $p = .002$; Wilk's $\boldsymbol{\lambda} = .80$, partial $\boldsymbol{\eta}^2 = .11$. Digging into this effect with ANOVAs, IJA did change with age, $F(3,93) = 7.71$, $p < .001$; partial $\boldsymbol{\eta}^2 = .20$, while distractibility did not, $F(3,93) = .19$, $p = .906$; partial $\boldsymbol{\eta}^2 = .01$. Tukey post-hoc testing showed the IJA changes were driven by the 34 month age group, all p's < .010. No other age group differed significantly from the others, all p's >. 050.

Due to the zero-inflated nature of the distribution of IJA scores, a follow-up non-parametric test was also run. A Kruskall-Wallis test still found a significant effect for age in IJA, H(3) = 11.58, $p = .009$, though only the contrast between 16- and 34-month-olds reached significance after Bonferroni correction, $p = .006$.

Relationship between JA and Distractibility

Our second aim was to investigate the potential relationship between JA and distractibility, expecting distractibility to increase as joint attention decreased. One-tailed correlations partialling out age group did not show a relationship between distractibility and either IJA, $r(92) = .15$, $p = .071$, nor RJA, $r(92) = .01$, $p = .466$.

One-tailed bivariate correlations were also run within each age group (Table 4). The correlation between RJA and distractibility was significant in 24-month-olds, $r(27) = -.47$, $p = .005$. A correlation between IJA and distractibility at 34-month-olds also reached a low *p*-value, though the result was not in the hypothesized direction, $r(22) = .36$, $p = .043$. All other correlations were not significant, *p*'s > .050.

Because of the skew present in the IJA and RJA distributions, we also conducted a series of Spearman correlations within age groups. Results were largely similar, though the RJA and distractibility correlation at 24 months was smaller, $r(27) = -.32$, $p = .048$, and the IJA and distractibility correlation at 34 months had a higher *p*-value, $p = .063$.

IJA in Social vs. Non-social Conditions

Finally, our third aim was explored by comparing IJA between the non-social and social conditions (Figure 4). There was a significant difference, $t(96) = -6.82$, $p < .001$, $d = .69$, with more IJA occurring during the social conditions ($M = 3.53$, $SD = 4.10$) than during the non-social conditions ($M = .78$, $SD = 1.34$). A follow-up 2 (non-social vs. social) by 4 (age group) ANOVA also revealed a significant interaction effect, $F(3,93) = 6.36$, $p = .001$. An inspection of the estimated marginal means with Bonferroni correction suggests the difference between social and nonsocial conditions may not hold for 16-month-olds, $p = .098$, but does for 24-, 31-, and 34-month-olds, all *p*'s <.020.

Table 3. Descriptive statistics of full sample (N = 98). IJA is a count of discrete episodes. RJA is a proportion of appropriate responses to the experimenter's bids (1 = relevant response to all bids). Distractibility is the proportion of time the child spent looking at the distractor during distractor conditions. *One participant from the 34 month age group was missing a portion of their data for one condition. This only affected the descriptives for IJA here (N = 23) and their data was retained for RJA and distractibility (N = 24).

Age Group (months)	N	IJA (SD)	RJA (SD)	Distractibility Proportion (SD)
16	24	2.50 (2.52)	.83 (.20)	.17 (.09)
24	29	3.59 (3.56)	.92 (.15)	.15 (.10)
31	21	3.43 (2.73)	.92 (.09)	.16 (.10)
34	24*	7.91 (6.72)	.93 (.13)	.16 (.10)

Table 4. Bivariate correlations between distractibility and IJA and RJA, within age groups. *Correlation was significant at $p < .05$ level, one-tailed. **Correlation was significant at $p < .01$ level, one-tailed. *Note*. The IJA correlation at 34 months is in the wrong direction for the one-tailed test.

Age Group (months)	IJA	RJA
16	.12	.16
24	.04	-.47**
31	-.05	.21
34	.36*	.15

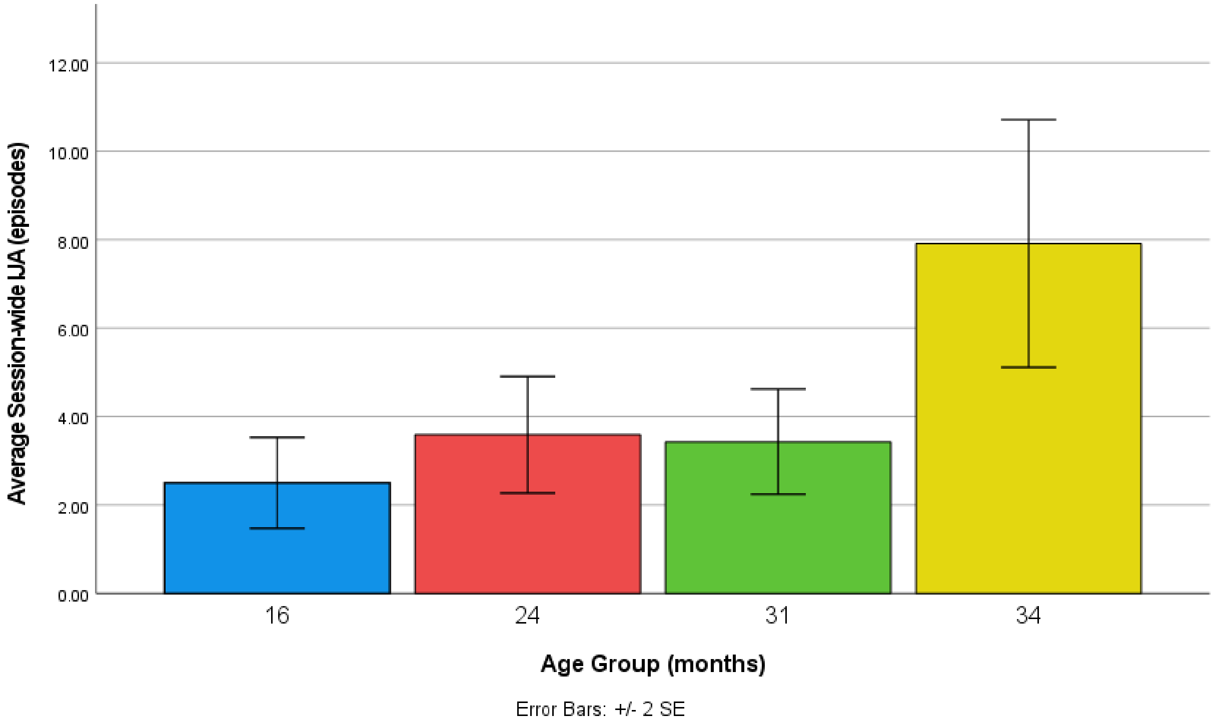

Figure 2. Average IJA episode count, broken down by age group.

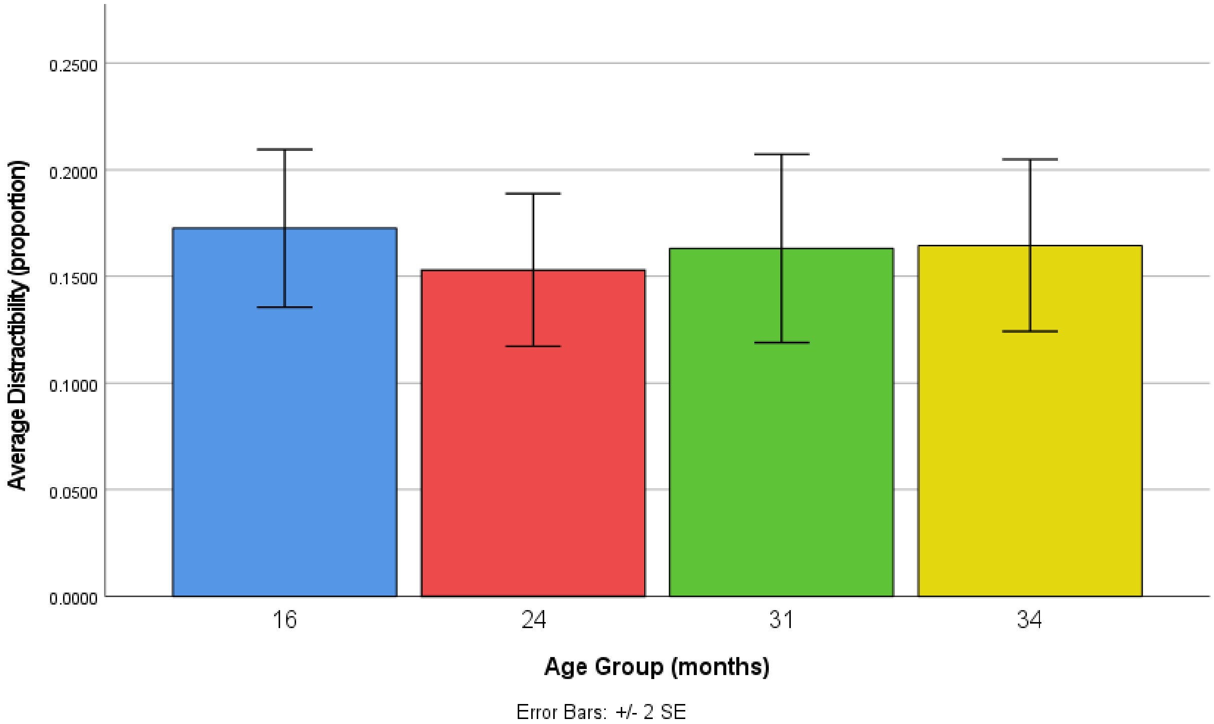

Figure 3. Average proportion of time spent distracted during distraction conditions, broken down by age group.

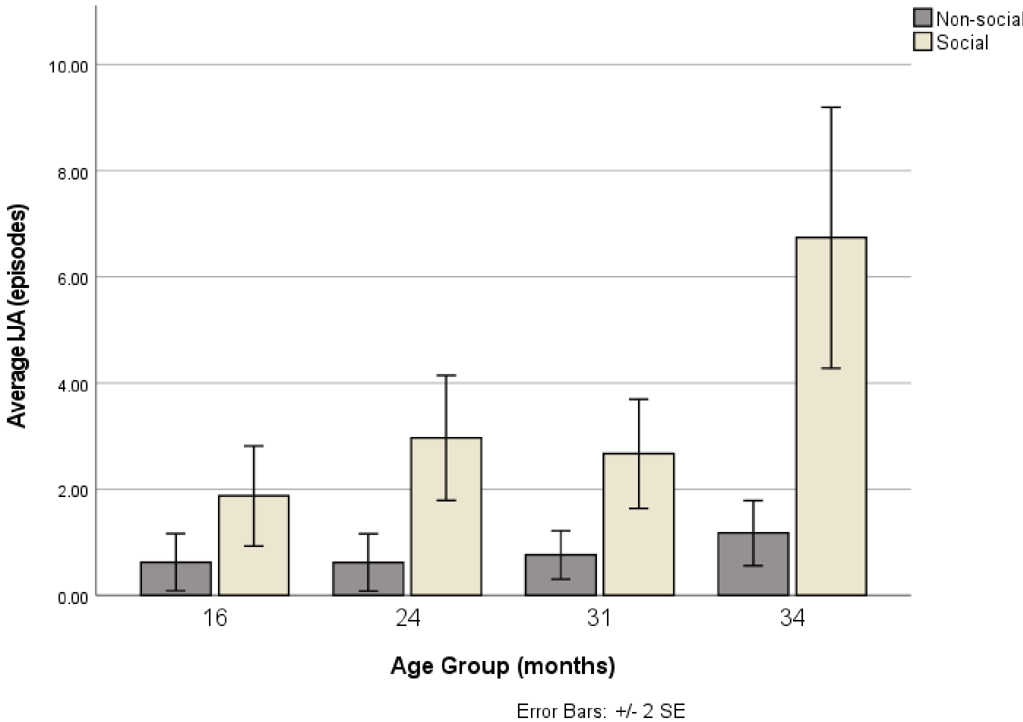

Figure 4. Average IJA episode count compared between non-social and social conditions.

CHAPTER 4

DISCUSSION

This project set out to answer questions concerning the development of joint attention and how distractibility relates to it in toddlers. To recap, we asked three research questions to answer this. Research Aim 1 asked whether we could replicate the age-related trends seen in the literature: a lack of significant change across our age range, with the possible exception of an increase in IJA for our older children. Research Aim 2 sought to extend the literature, by asking if there was a relationship between IJA and distractibility. Finally, Research Aim 3 explored the question of the influence of an active social partner on IJA.

Before discussing individual aims, there are a few considerations worth bearing in mind as we analyze the results. The distribution of IJA and RJA scores were non-normal: IJA was heavily positively-skewed, especially for Research Aim 2 where 63.3% of the data points used were at floor, having zero IJA episodes. On the other extreme, RJA had a highly negatively-skewed distribution, with 59.2% of the entire sample being at ceiling, responding to all joint attention bids the experimenter started. It is possible that this data distribution made it unlikely to detect effects; in particular, results could have fallen more in line with expectations if the procedure encouraged more IJA from the children. For RJA, on the other hand, studies that have also had high sample rates of RJA have still detected correlations, such as in studies of language outcomes (Tomasello & Farrar, 1986; Mundy & Gomes, 1998; Mundy et al., 2007). Thus, while our IJA distribution is of potential concern, RJA distributions that are non-normal have still been associated with significant findings in the literature previously.

Additionally, it might be worth considering whether our operationalizations of our key variables of interest are sufficiently comparable to previous studies. RJA was fairly similar to typical operational definitions (e.g., Mundy et al., 2007; Gago Galvagno et al., 2019). On the other hand, IJA is frequently measured in very controlled situations that are set up to encourage the child to engage in joint attention. In ESCS studies, for example, there are a limited number of salient stimuli simultaneously present in the environment and the experimenter acknowledges the bids that the child initiates (e.g., Mundy et al., 2003). While the present study provided a free-play environment which allowed children to initiate bids, the procedure also included distractions and an experimenter partner who was instructed to ignore the child's bids for the first half of the session. Thus, these methodological differences in IJA elicitation might lead to different results regarding IJA's connection to distractibility, compared to previous studies.

Our distractibility definition also had some methodological differences from other distractibility studies in the literature. Compared to JA, operational definitions of distractibility in the literature are more varied, depending on the modality of the distractor and what behaviors are within the participants' capabilities. An age-appropriate outcome that could have been measured here, instead of the time proportion we used, include proportions of distractors looked at (Ruff & Capozzoli, 2003) or latency to look at the distractor (Richards & Turner, 2001; Kannass et al., 2006). While we feel time proportion was a valid way to measure distractibility with precedent in the toddler literature (e.g., Kannass et al., 2010; Schmidt et al., 2008), it is worth considering these differences when comparing our results to other distractibility research.

In regards to Research Aim 1, our results partly agree with the existing literature. As expected, IJA increased with age, with this age effect being chiefly driven by the oldest age group, the 34-month-olds. Research that has examined age effects for IJA in typically developing populations has tended to examine 2-year-olds and younger, leaving the period past infancy less explored. IJA does not seem to have a simple linear increase in IJA in the 12-18 month range (Sheinkopf et al., 2004; Mundy et al., 2007). Our results are consistent with this pattern: a lack of difference in IJA count in our younger participants.

Other research has found different patterns of results, however. For example, Landa et al. (2013) found an increase in IJA between 14 and 24 months, while Adamson and colleagues (2021) found a small increase across 12 to 30 months. Gago Galvagno et al. (2021) used an age range similar to the present study and reported IJA counts between their younger and older age groups that were very similar to each other; while Gago Galvagno did not report any tests of differences between these values, means and SDs were very close to each other. The results of each of these studies show patterns in IJA we did not replicate.

One interpretation of these past and present findings may be that somewhere between 31- and 34-months of age is a transitional period where a child begins to initiate more joint attention bids. Gago Galvagno's older age group included 30-36 month old children. It is possible that, because the present study had two separate age groups that fell within this age range, 31- and 34-month-olds, the present study was able to detect an age-related change in this window that may have been washed out in the broader, 30-36 month age grouping used by Gago Galvagno. However, further work in the 16-30 month range may be needed to reconcile both Landa and colleagues' (2013) and Adamson et al.'s (2021) findings.

Our distractibility results largely agreed with past literature in that we did not find any age-related effects, even in the oldest age group. Most past research has found a lack of age-related changes in distractibility before 6 years of age (Richards & Turner, 2001; Oakes et al., 2004; Kansass et al., 2006; Anderson et al., 1987), but demonstrable age-related change for 6 year-olds onward through childhood (Hoyer et al., 2021). In contrast, Ruff and Capozzoli (2003) did find age-related declines in distractibility across 10-, 26-, and 42-month-olds. Operationalization differences could explain this discrepancy. Ruff and Capozzoli's operationalization was similar to Anderson and colleagues, who examined 3- and 5-year-olds, while the other studies of distractibility in young children looked at ages younger than 3 years. Ruff and Capozzoli may have captured one facet of distractibility that does change over the first three and a half years, but is stable from three to five years. In short, our results agree with the majority of the literature, finding a lack of age-related change in distractibility over our age range.

For Research Aim 2 we expected to find a link between distractibility and joint attention, but had null results outside of a correlation among 24-month-olds for distractibility vs. RJA. Because executive control networks manage attentional capacities such as sustained and selective attention, both of which are important to JA and distractibility, we expected to find a negative relationship across our age range. The previously discussed operationalization and psychometric issues with the data may also play a role in our findings. A more normally-distributed set of IJA data, or an alternative operationalization of distractibility may have found a relationship that we did not uncover in the present analyses. It is also possible that there are other mechanisms for the connection between JA and executive function that a measure of distractibility does not capture.

However, there may be ways that our pattern of results for Research Aim 2 agree with existing studies. In their study of executive function and joint attention, Gago Galvagno et al. (2021) used a similar age range in their study (18-36 month-olds) and only found a relationship between executive function and RJA, but not between executive function and IJA. The other two studies of this type (Miller & Marcovitch, 2015; Gago Galvagno et al., 2019) had younger samples (14-18 month-olds and 18-24 month-olds, respectively) and also found some relationship between RJA and executive function. While Miller and Marcovitch did find a positive relationship between more display of advanced IJA behaviors and executive function success, only Gago Galvagno et al. (2019) found a relationship for executive function with both general IJA count and RJA success rate. One interpretation of these results could be that executive function skills broadly, and the kinds of attention-directing skills relevant in the present study more specifically, are relevant to JA in the second year; after this window, the relationship between JA and executive function may be weaker. Indeed, while Gago Galvagno et al. (2021) reported a relationship between RJA and executive function across their 18-36 month old sample, they found the relationship stronger in the 18-24 month age group. The lack of findings for IJA, and the lack of a significant correlation for RJA in our 16-month-olds, could represent a greater influence of task demands while executive function is still early in development; Miller and Marcovitch reported some correlations for both IJA count and RJA success with some individual EF tasks but not others.

Research Aim 3 was exploratory, though showed the clearest results: during conditions involving an interactive social partner, children initiated much more IJA. While exploratory, it is hardly surprising that an active social partner encourages more social interaction. That said, examinations of IJA predictors have tended to focus on stable, longer-term influences. For example, some have argued that individual differences in IJA may be influenced by temperamental differences in social motivation (Mundy et al., 2007), or differences in the scaffolding behavior (directing, showing, demonstrating) that caregivers exhibit even months earlier (Vaughan et al., 2003; Gaffan et al., 2010). Even studies of interventions targeting JA skills (e.g., Kasari et al., 2006; Kasari et al., 2010; Goods et al., 2013; Shih et al., 2021) tend to measure JA pre- and post-intervention, not during. To our knowledge, this is one of the first studies to present evidence of IJA changes following experimental manipulation within the same session. Thus, the present study suggests that IJA may also be susceptible to shorter-term, environmental influences.

The comparisons between non-social vs. social IJA should be interpreted with caution, however. This was an exploratory analysis pulled from data not designed to compare these measures. Further, order effects may be a concern in interpreting these results, given that the two social conditions always followed the two non-social conditions. The increase in IJA from non-social to social conditions could represent the child warming up to the situation more than any effects specific to the manipulations. To properly test the short-term effects of partner scaffolding on IJA, a novel study should randomize the order of non-social and social conditions. Examining rates of IJA across a still-face procedure could also be fruitful for enriching our understanding.

In summary, the present research project partly replicated trends in the literature for age-related change, or lack thereof, for IJA and distractibility. The relationship between RJA and distractibility at 24 months may be worth further investigation. However, the ties between executive function and JA may be better mediated by other executive function capacities, or alternatively the 24-36 month age range represents a transition period where executive function capacities are less crucial to JA. These questions could be better explored with a research study designed with them in mind from the start. Finally, our exploratory question of the influence of the immediate social environment on IJA deserves further study, as this may better inform our understanding of short-term influences on JA.

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APPENDICES

Appendix A. Coding scheme used for child behaviors during the session.

Code	**Description**
IJA	Child alternating gaze between an adult in the room (experimenter or caregiver) and a third object. Vocalizations may accompany the behavior.
RJA	Child responds to experimenter's joint attention bids (example behaviors: looks at experimenter, follows experimenter's point, or picks up indicated object).
Distracted	Child is looking towards the TV while it is playing a distractor clip. Code ends when the child looks away, even if the clip terminated already.
TV	Child is looking towards the TV while no clip is playing.
Focused attention	Child is actively manipulating and looking at the toy available to them.
Casual attention	Child is manipulating the toy but their attention is elsewhere (e.g., looking around the environment).
Parent	Child looks towards the parent without any obvious joint attention bid.
Experimenter	Child looks towards the experimenter without any obvious joint attention bid.
Other	Child is looking somewhere in the environment that is not already covered in the other codes.
Unusable	Child is fussy or their data is otherwise unusable during this period; not used in data analyses outside of descriptive statistics.