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The Origins of Theory of Mind in Infant Social Cognition: Investigating Longitudinal Pathways from Intention Understanding and Joint Attention to Preschool Theory of Mind

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Abstract

A growing body of literature has established longitudinal associations between key social cognitive capacities emerging in infancy and children's subsequent theory of mind. However, existing work is limited by modest sample sizes, narrow infant measures, and theory of mind assessments with restricted variability and generalizability. The current study aimed to extend this literature by (a) recruiting a large sample of participants ($n = 116$; 53 boys; 63 girls; all U.S. residents; 88 White, 8 Hispanic or Latino, 2 Black or African American, 14 two or more races/ethnicities, 4 unknown; median family income: $74–122,000), (b) examining multiple measures of infant social cognition (intentional action understanding, responding to joint attention, initiating joint attention) at Time 1 (8–12 months), and (c) using an ecologically valid theory of mind assessment designed to capture individual differences in preschoolers' mental state understanding (the Children's Social Understanding Scale; Tahiroglu et al., 2014) at Time 2 (37–45 months). Measured variable path analysis revealed a significant longitudinal association between infants' initiating joint attention and later theory of mind: infants who engaged in more attempts to initiate joint attention with experimenters through gaze alternation or gestures went on to show better parent-reported mental state understanding as preschoolers. Notably, the paths from infants' responding to joint attention and intentional action understanding to later theory of mind did not emerge as significant. These findings bolster and clarify existing claims about how mental state reasoning is rooted in foundational social-cognitive capacities emerging in infancy.

Keywords

theory of mind; social cognition; joint attention; intention understanding

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From early in development, children interpret the behavior of others as motivated by internal mental states such as beliefs, desires, intentions, and knowledge. Evidence for this foundational conceptual capacity, known as theory of mind, can be observed in preschool children's talk about what people think, feel, want, and know (e.g., Bartsch & Wellman,

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1995; Hughes & Dunn, 1998), as well as by their success on standard theory of mind measures, such as the false belief task (e.g., Wellman et al., 2001). The origins of children's understanding of others in terms of internal mental states, however, can be found much earlier than the preschool years. Indeed, a large body of research has revealed key social-cognitive abilities present in the first year of life, including the ability to understand the goal-directed nature of human action (see Woodward et al., 2009 for a review) and the capacity to engage in joint-attentive interactions with social partners (e.g., Bakeman & Adamson, 1984; Carpenter et al., 1998; Mundy et al., 2007). The current study aimed to examine longitudinal relations between these social-cognitive abilities observed in infancy and children's later theory of mind. In particular, using a robust sample size and a theory of mind measure designed to capture individual differences, we tested whether intentional action understanding and joint attention abilities in the first year of life predict children's mental state understanding during the preschool years.

There are several theoretical reasons to expect developmental continuity in social cognition from infancy to childhood. First, consistent with some constructivist accounts of theory of mind development, early social-cognitive concepts may serve as conceptual prerequisites for more advanced mental state knowledge (e.g., Tomasello, 1995; Wellman, 2014). According to this view, complex mental state concepts—such as an understanding of knowledge and belief—may be built on the foundation of a more basic understanding of action and intentional agency. A second (non-mutually exclusive) reason to expect developmental continuity is that early social-cognitive capacities may afford opportunities to engage with and learn about others' mental states (e.g., Barresi & Moore, 1996; Carpendale & Lewis, 2004; Liszkowski, 2013; Mundy & Newell, 2007; Tomasello, 2018). Specifically, infants who are better able to read the intentions underlying others' actions and who can more effectively participate in joint-attentive social interactions may have more frequent and richer experiences to inform their developing theory of mind. Finally, it is possible that stable, trait-like individual differences may underlie variability in social-cognitive capacities across early development. Developmental continuity in characteristics such as social attention or social motivation (e.g., Chevallier et al., 2012; Mundy & Acra, 2006), in particular, may manifest in better infant social cognition as well as more advanced preschool theory of mind.

In recent decades, a growing body of literature has indeed documented longitudinal pathways from infant social cognition to childhood theory of mind (Aschersleben et al., 2008; Brink et al., 2015; Brooks & Meltzoff, 2015; Charman et al., 2000; Colonnesi et al., 2008; Filippi et al., 2020; Kloo et al., 2020; Kristen et al., 2011; Nelson et al., 2008; Olineck & Poulin-Dubois, 2007; Sodian et al., 2016, 2020; Sodian & Kristen-Antonow, 2015; Thoermer et al., 2012; Wellman et al., 2004, 2008; Yamaguchi et al., 2009). Of focus here is intriguing longitudinal associations between childhood theory of mind and both infants' meaningful processing of intentional actions and their joint attention abilities.

Early Intentional Action Understanding and Later Theory of Mind

A large literature has established that infants come to interpret the actions of others as goal-directed and intentional during the first year of life (e.g., Brandone & Wellman, 2009; Gergely et al., 1995; Woodward, 1998; see Woodward et al., 2009 for a review). More recently, multiple studies have also discovered longitudinal relations between this intentional action understanding observed in infancy and theory of mind in the preschool years (Aschersleben et al., 2008; Filippi et al., 2020; Sodian et al., 2016; Wellman et al., 2004, 2008; Yamaguchi et al., 2009). In general, these studies have explored links between infants' attention to goal-directed actions in looking-time paradigms and their later performance on theory of mind tasks (see Filippi et al., 2020 for related neural evidence). For example, Wellman and colleagues (2008) showed that 10- to 12-month-olds' attention to displays of intentional action predicted their false belief performance at age 4 (when controlling for IQ, vocabulary, and inhibitory control). Similarly, Aschersleben et al. (2008) demonstrated that decrements of attention to displays of intentional actions as early as 5 to 7 months of age also predicted false belief performance at age 4 (when controlling for concurrent language abilities). Together, this work has been taken as support for a specific link between early intentional action processing and later theory of mind.

However, there are two key limitations to this body of work. First, all of the studies exploring longitudinal relations between infants' action understanding and later theory of mind have relied on relatively small samples, ranging from 17 participants in Yamaguchi et al. (2009) to 45 in Wellman et al. (2008). Given growing concerns about statistically underpowered studies with small sample sizes—including the greater likelihood of observing a false positive result (e.g., Bakker et al., 2012; Button et al., 2013; Oakes 2017), it is important to examine whether the observed associations hold in properly powered studies with more robust sample sizes.

Second, although each of these studies demonstrated some form of continuity in social cognition from infancy to the preschool years (see Poulin-Dubois et al., 2020 for a related exception), there are also notable discrepancies in their patterns of results. Some studies showed significant associations with infants' decrement of attention during initial habituation or familiarization events and not with infants' looking time preference on test events (Aschersleben et al., 2008; Wellman et al, 2004, 2008); others showed the inverse pattern (Sodian et al., 2016; Yamaguchi et al., 2009). Among the studies showing significant decrement of attention effects, the direction of the effects also differed. Whereas Aschersleben et al. (2008) and Wellman et al. (2004) found a theory of mind advantage for children who as infants habituated to intentional action displays faster, suggesting more efficient early intentional action processing, Wellman et al. (2008) found a theory of mind advantage for children who as infants spent *more* time looking at the intentional action displays. These inconsistencies are interpretable given methodological differences including the age of the infants tested, the intentional actions being displayed, and the use of habituation versus familiarization designs. However, these discrepancies also raise questions about the precision of the observed effects. Thus, although the bulk of existing evidence rests in favor of the claim that early intentional action processing predicts later theory of mind, more research is needed to substantiate this hypothesis.

Early Joint Attention and Later Theory of Mind

At the same time that infants' intentional action understanding is emerging, infants also show development in their ability to coordinate attention between a social partner and an object of mutual interest, known as joint attention (Bakeman & Adamson, 1984; Carpenter et al., 1998; see Brandone et al., 2020; Brune & Woodward, 2007; Dunphy-Lelii et al., 2014 for evidence of links between intention understanding and joint attention). Longitudinal studies confirm that across the first year of life, infants show increasing proficiency in both responding to others' joint attention bids (by following others' gaze or gesture to a shared point of reference), as well as initiating joint attention (by using gaze or gesture to direct others' attention to an object or event; Carpenter et al., 1998; Mundy et al., 2007; for evidence of variation in the construct of joint attention across individuals and socio-ecological contexts, see Akhtar & Gernsbacher, 2008; Bard et al., 2021). The development of joint attention is critical (e.g., Mundy & Newell, 2007), as individual differences in joint attention have been shown to contribute to a range of other developmental achievements, including language (Mundy et al., 2007; but see Akhtar & Gernsbacher, 2007), social competence (Van Hecke et al., 2007), and self regulation (Van Hecke et al., 2012).

Explorations of longitudinal pathways from infant joint attention to later theory of mind have also proven promising. Studies show links between theory of mind during the preschool years and earlier assessments of infants' responding to or comprehension of joint-attention behaviors (Brooks & Meltzoff, 2015; Colonnesi et al., 2008; Kristen et al., 2011). For example, Kristen et al. (2011) showed that infants' ability to follow others' pointing gestures at 9 months of age predicted their use of mental state language at 24 and 36 months (controlling for general language abilities at 18 months). The literature also shows evidence of longitudinal pathways from infants' initiating joint attention behaviors to later theory of mind (Charman et al., 2000; Sodian & Kristen-Antonow, 2015). For example, infants' use of points to direct attention at 12 months of age predicted false belief scores at age 4 (controlling for gender and language skills; Sodian & Kristen-Antonow, 2015). Together, these studies provide strong initial support for the view that joint attention capacities present in infancy lay the foundation for later theory of mind development (see Brink et al., 2015, and Nelson et al., 2008 for related findings).

However, these studies are also limited by relatively modest sample sizes, ranging from 13 participants in Charman et al. (2000) to 54 in Sodian and Kristen-Antonow (2015). Discrepancies within this body of evidence also highlight the need for additional work. For example, gaze following emerged as a significant predictor in Brooks and Meltzoff (2015), but not in Kristen et al. (2011). Moreover, there are inconsistencies across the existing work in the role of infants' comprehension and production of points with imperative and declarative goals (Colonnesi et al., 2008; Kristen et al., 2011; Sodian & Kristen-Antonow, 2015). Thus, although the existing evidence supports the idea of continuity between infant joint attention and childhood theory of mind, additional research is needed to confirm and clarify this developmental pathway.

The Present Study

The overarching goal of the present study was to extend the existing literature by providing a systematic new investigation of the longitudinal pathways between infant social cognition and preschool theory of mind. First, we aimed to address potential concerns regarding the relatively small sample sizes tested previously by conducting a sufficiently powered study with a more robust sample size. Our final sample of over 100 participants more than doubles the largest sample used in prior studies.

Second, we aimed to provide a comprehensive examination of the relevant social-cognitive capacities in infancy by assessing both intentional action understanding and joint attention in the same infants at Time 1. We assessed intentional action understanding using an eye-tracking paradigm designed to examine infants' ability to generate predictions about an agent's intentional actions as they unfold over time. Anticipatory looking measures have been used frequently in the literature on infants' action understanding (e.g., Brandone et al., 2014; Cannon & Woodward, 2012; Falck-Ytter et al., 2006; Hunnius & Bekkering, 2010); however, they have not yet been employed in work examining links with later theory of mind. We chose an anticipatory looking approach (in contrast to the looking-time paradigms used in prior longitudinal research) because the prospective understanding of action measured by anticipatory looking has been argued to be critical for online action processing and thus measures of anticipatory looking provide a particularly stringent test of intentional action understanding (Cannon & Woodward, 2012; Krogh-Jespersen et al., 2015). We examined infants' ability to generate predictions about a *failed* reaching action, specifically, because actions in which the observed patterns of motion (e.g., reaching for but failing to grasp a ball) are distinct from their intentions (e.g., grasping and retrieving a ball) have also been argued to provide an especially rigorous test of intention understanding (Brandone & Wellman, 2009; Meltzoff, 1995). To assess joint attention, we examined two broad yet distinct subtypes of joint attention as emphasized by Mundy and colleagues (2003): Responding to joint attention (RJA) was assessed through standardized gaze-follow and point-follow tasks (Carpenter et al., 1998) and initiating joint attention (IJA; e.g., shows, points, gaze alternation) was observed during structured interactions with an experimenter (Mundy et al., 2003).

Finally, we aimed to provide a nuanced assessment of theory of mind at Time 2 by utilizing an ecologically valid measure designed to capture individual differences in mental state reasoning. Instead of assessing theory of mind through laboratory tasks such as the standard false belief task (Wimmer & Perner, 1983) or the Theory of Mind Scale (Wellman & Liu, 2004), we chose to implement the Children's Social Understanding Scale (CSUS; Tahiroglu et al., 2014). The CSUS is a parent-report survey measure that utilizes parents as informants on their children's theory of mind. The CSUS is particularly well suited for the goals of the current study because it was specifically designed to (a) index individual differences in theory of mind, (b) offer ecological validity by relying on informants who have observed the child in a range of different circumstances across time, and (c) capture the multifaceted nature of theory of mind by assessing a wide range of mental state concepts through subscales of belief, knowledge, perception, desire, intention, and emotion understanding (Tahiroglu et al., 2014). The CSUS has been shown to have strong psychometric properties, including high internal consistency, strong test-retest reliability, and good construct validity. Importantly, scores on the CSUS have been shown to correlate significantly with children's performance on researcher-administered theory of mind tasks when controlling for age, verbal ability, and working memory, with populations of typically developing children and children with mild intellectual disabilities, hearing impairment, and autism spectrum disorder, and in multiple cultures and languages (e.g., Besiroglu et al., 2022; Białecka-Pikul & Stępień-Nycz, 2019; Ekerim-Akbulut et al., 2021; Gluck et al., 2020; Smogorzewska et al., 2019; Tahiroglu et al., 2014). The CSUS has been used successfully in prior research as the primary measure of individual differences in theory of mind (e.g., Filippi et al., 2020; Resendes et al., 2021; Tompkins, 2022) and thus serves as a strong measure for the purposes of the current study.

Consistent with prior work (e.g., Aschersleben et al., 2008; Brooks & Meltzoff, 2015; Kristen et al., 2011; Sodian et al., 2016; Wellman et al., 2008) and theoretical accounts proposing developmental continuity in social cognition from infancy to childhood (e.g., Carpendale & Lewis, 2004; Wellman, 2014), we predicted that infants who showed better social-cognitive abilities at Time 1 would show more advanced theory of mind at Time 2. We also expected differential patterns might emerge from each of the infant measures (intentional action understanding, responding to joint attention, initiating joint attention) to later theory of mind; however, we did not make specific predictions about unique developmental pathways.

Method

Participants

Participants in the current study were initially recruited to participate in a set of studies investigating the development of social cognitive abilities in infancy. (More information about the original studies can be found at https://osf.io/xfkyv/). Participants were recruited from birth records in a midsize city in the Northeastern United States. An initial sample of 209 infants between 8 and 12 months of age participated. When participants were roughly 3.5 years of age, participants' parents were invited via email to complete an online questionnaire assessing their child's theory of mind. 116 parents responded and their children served as the focal sample for the current study. Analyses showed no association between whether or not parents contributed Time 2 data and infant race or gender (Chi-square test of independence: *p*s > .18). Moreover, infants that did and did not contribute Time 2 data did not differ significantly on the basis of family income or maternal education (Mann-Whitney test: *p*s > .09). (A subset of the original sample of infants also returned to the lab during the toddler years to participate in a study about prosocial behavior (Laible et al., 2021). See Stout et al. (2021) for an examination of the longitudinal links between infant social cognition and toddler prosocial behavior.)

The final sample included 53 boys and 63 girls. They were predominantly White (88 White, 8 Hispanic or Latino, 2 Black or African American, 14 selected two or more races and ethnicities, 4 did not respond), and most came from middle-class families (median family income of $74–122,000) with college-educated mothers (49 completed a college degree, 45 completed a graduate degree, 15 completed some college, 4 received no more than a high school degree, and 3 did not respond). At Time 1, infants ranged from 8 to 12 months of age (M = 9.36, SD = .98). At Time 2, children ranged from 37 to 45 months of age (M = 40.36, SD = 1.67). The time between the Time 1 and Time 2 data collection points ranged from 26 to 36 months (M = 30.99, SD = 2.01).

A statistical power analysis performed using the moderate effect sizes observed in prior work for the Spearman rank-order correlation between infant social cognition and later theory of mind (e.g., Aschersleben et al., 2008; Kristen et al., 2011; Sodian & Kristen-Antonaw, 2015; Wellman et al., 2008) and alpha and power levels set at .05 and .80, respectively, suggested a recommended sample size of approximately 90 participants. Thus, our sample of 116 participants is more than adequate for the central objectives of this study.

Measures and Procedures

All procedures involving human subjects in this study were approved by the Institutional Review Board at Lehigh University.

Time 1: Infant Social Cognition—At Time 1, infants completed a series of assessments of their social-cognitive capacities during a 90-minute laboratory visit. The focal measures examined here include intentional action understanding, responding to joint attention (RJA), and initiating joint attention (IJA). The stimulus video for the intentional action understanding task, coding procedures for the joint attention tasks, and the full list of tasks infants completed that are beyond the scope of this study (e.g., non-social anticipatory looking, means-end behaviors, self-locomotion, successful action understanding, social obstacle, imperative gesture, free play) are available at https://osf.io/xfkyv/.

Intentional Action Understanding: Intentional action understanding was assessed using an eye-tracking paradigm designed to examine infants' ability to generate predictions about a failed reaching action (Brandone et al., 2014). Infants were presented with a video sequence (7200 ms in duration) in which an agent reaches for but fails to retrieve a ball. In the video, the agent is seated at a table in front of a barrier and the ball. He peers over the barrier at the ball and then reaches in an arcing motion over the barrier, narrowly missing the ball. The agent pauses briefly with his hand hovering over the ball, and then brings his arm back to his torso. The video freezes with the man looking down at his empty hand (800 ms in duration). Infants were shown 10 repetitions of this event alternated with an attention-getting stimulus. Given decreases in attention across the 10 trials, only the first 5 trials are included in analyses. On the first trial only, the initial frame of the video was presented for 2000 ms before the video began in order to orient infants to the scene. Some infants saw the actor seated on the left side of the screen and reaching for a ball on the right; others saw the reverse.

Videos were presented on a 24-inch Tobii T60XL corneal reflection eye-tracking system (Sampling rate: 60 Hz; Accuracy: 0.5 to 1 visual degree; Tobii Technology, Sweden). Infants were seated approximately 60 cm from the screen. The eye tracker was calibrated for each infant using a 5-point procedure implemented in Tobii Studio. Video presentation was then controlled by PsyScope X and the TobiiPlus interface.

Eye-tracking data processing was carried out in R (Version 3.3.2; R Core Team, 2017). A circular area of interest (AOI) was defined manually around the ball. The AOI extended approximately 1° beyond the perimeter of the ball. This buffer is consistent with prior work (Brandone et al., 2014), standards in the field (see Gredebäck et al., 2009), and estimates of inaccuracies in the Tobii system (0.5 to 1.0°). In the current study, we focused on the latency of participants' gaze shifts to the ball AOI on each trial. As in prior work (Brandone et al., 2014), we classified looks as anticipatory if they arrived at the AOI before the actor's hand was roughly 2 visual degrees away from the ball. This distance was selected because it reflects the gap between the ball and the actor's hand at the full extension of the failed reach.

Infants' performance on each trial was scored categorically. First, trials on which infants watched the full screen for less than 50% of the reaching action were dropped from analyses (12.4% of trials). The remaining trials were each given a score ranging from 0 to 2. Trials on which infants looked at the AOI before the anticipatory look cut-off (26.9% of trials overall) were given a score of 2. Trials on which infants looked at the AOI but did so after the anticipatory look cut-off were given a score of 1 (27.4% of trials). Finally, trials on which infants did not look at the AOI at all were given a score of 0 (33.3% of trials). Two infants watched the full screen for less than 50% of the reaching action on all five trials and thus were missing intentional action understanding data. For the remaining 114 infants, the mean score across Trials 1 to 5 was calculated for use in focal analyses, with higher scores indicating better prospective intentional action understanding.

Responding to Joint Attention (RJA): Infant RJA was assessed using gaze-follow and point-follow tasks modeled after those used by Carpenter et al. (1998). Infants were seated in a highchair at a small table directly across from an experimenter. Objects (e.g., large stickers, stuffed animals) on the left and right walls served as the targets of the experimenter's joint attention bids. Infants were given a small toy to hold throughout the tasks.

In both tasks, the experimenter first called the infant's name and waited for them to make eye contact. In gaze-follow trials, the experimenter then vocalized excitedly (e.g., "oh!") and made a deliberate look to the side of the room at one of the target objects on the wall. The experimenter alternated her gaze between the infant and the object until infants either followed her attention to the target object or had clearly seen four head turns. Point-follow trials were identical except that the experimenter also used her index finger to point to the target object (in a cross-body motion) and maintained this pointing gesture throughout the duration of the trial. Infants received two gaze-follow and two point-follow trials with the target alternating between the left and right side of the room.

Each trial was scored by a trained researcher for whether or not the infant followed the experimenter's cues and looked toward the target object. Intercoder reliability was established by an independent coder who scored 35% of participants' recordings. Coders agreed on gaze-follow scoring 95% of the time, Kappa = .90, and point-follow scoring 91% of the time, Kappa = .82. In cases of disagreement, the primary coder's score was used. The proportion of successful follows across the four trials (two gaze-follow and two point-follow) was calculated for use in analyses. Three infants were missing RJA data due to sibling interference (*n* = 1) and squirminess or fussiness that prevented completion of the tasks (*n* = 2).

Initiating Joint Attention (IJA): Infant IJA was assessed using two tasks involving an experimenter and a set of toys. Infants were seated in a high chair at a small table across from the experimenter. The first task was a 2-minute structured play session. The task began after the experimenter arranged a set of toys on the table in front of the infant. Every 30 seconds, the experimenter briefly engaged the infant with a toy. During the rest of the session, she remained neutral and responded only following infants' looks to her face. Responses included positive facial expressions, nodding, and brief verbal comments. The second task was an object spectacle task modeled after Carpenter et al. (1998). Two remote-activated toys were positioned on either side of the room behind the experimenter and outside of her line of sight. During the task, each toy was activated surreptitiously for 30 seconds and the experimenter pretended not to notice.

Both tasks were coded by a trained researcher for a series of IJA behaviors using a coding scheme inspired by Mundy et al. (2003) and implemented in Stout et al. (2021). Coded behaviors included pointing (clear extension of the index finger toward an object in the room), showing (presenting a toy in front of the researcher's face while looking at the researcher), and reaching for distal objects (deliberately extending an arm toward a distant object). The object spectacle task was also coded for gaze alternation between the active object and the researcher's eyes (Mundy et al., 2003). The total number of behaviors of each type was calculated for each infant and an overall IJA score was calculated by summing across the four behavior types. Intercoder reliability was established by an independent coder who coded 34% of participants' data. Coders agreed that an IJA behavior occurred 90% of the time and IJA scores were strongly correlated across coders, *r* = .95. In cases of disagreement, the primary coder's score was used. Four infants were missing IJA data due to sibling interference (*n* = 1), video recording issues (*n* = 1), and fussiness that prevented completion of the tasks (*n* = 2).

Time 2: Theory of Mind—At Time 2, parents completed an online version of the Children's Social Understanding Scale (CSUS; Tahiroglu et al., 2014). This survey includes 42 items, with 7 items from each of 6 domains of mental state understanding: belief, knowledge, desire, perception, intention, and emotion. The CSUS asks parents to evaluate their child's theory of mind through items taking a variety of forms, including direct assessments about particular types of mental state knowledge (e.g., "Understands that wishes don't always come true"), items about mental state language use (e.g., "Talks about what people think or believe"), and items about behaviors that reveal mental state understanding (e.g., "Is good at playing hide and seek"). Parents rated each item on a 4-point scale ranging from 1 (Definitely Untrue) to 4 (Definitely True). A "Don't Know" option was also provided. The CSUS showed excellent internal consistency in the current study (Cronbach alpha = .94). Based on prior evidence suggesting CSUS scores reflect a single global theory of mind factor as opposed to distinct factors for each subscale (e.g., Besiroglu et al., 2022; Smogorzewska et al., 2019; Tahiroglu et al., 2014), we created a composite CSUS score for use in analyses by averaging across all items (excluding “Don’t Know” responses), with higher scores indicating more advanced theory of mind.

Results

Analysis Plan

Our focal analysis estimated the paths from participants’ Time 1 social-cognitive abilities to their Time 2 theory of mind using measured variable path analysis implemented through Mplus Version 8.5 (Muthén & Muthén, 2020). Full information maximum likelihood estimation was used to accommodate missing data, with rescaling corrections to standard errors to deal with potential nonnormality in the data. Model fit was evaluated using the comparative fix index (CFI); root mean square error of approximation (RMSEA); and standardized root mean square residual (SRMR).

The model included paths from the Time 1 social-cognitive constructs (intentional action understanding, RJA, and IJA) to Time 2 theory of mind (overall CSUS score). All Time 1 measures were allowed to covary. Given variability in the age at which participants completed the Time 1 (8 to 12 months) and Time 2 (37 to 45 months) measures, infant age was included as a Time 1 covariate and preschooler age was included as a Time 2 covariate. Child gender, maternal education, and family income were also considered as potential covariates based on initial correlational analyses between these demographic variables and the central measures of social cognition. Nonparametric Spearman rank-order correlations were used to account for nonnormality in the infant measures. Gender was significantly related to Time 1 intentional action understanding, $r(112) = .25$, $p = .007$, and RJA, $r(111) = .27$, $p = .004$, with girls showing better intentional action understanding ($M_{\text{girls}} = 2.09$; $M_{\text{boys}} = 1.76$) and higher RJA scores ($M_{\text{girls}} = 0.63$; $M_{\text{boys}} = 0.43$). Thus, gender was included as a covariate at Time 1 and Time 2. Maternal education and family income were unrelated to any of the Time 1 or Time 2 measures and thus were not examined further.

Descriptive Statistics and Initial Correlations

Descriptive statistics for the Time 1 and Time 2 measures and the correlation matrix for the variables of interest are presented in Table 1. Nonparametric Spearman rank-order correlations are reported given nonnormality in the infant measures.

Time 1 Descriptives—As in prior work (e.g., Brandone et al., 2014; Brandone, 2015) performance on the intentional action understanding task varied considerably, ranging from a small group of infants (7%) who generated anticipatory looks to the goal of the failed reaching action on every trial to others (18%) who never fixated on the actor’s goal across the 5 trials. The mean intentional action understanding score of 0.94 suggests that, on average, infants were looking to the goal of the failed reaching action but doing so after the anticipatory look cut-off. Infants’ intentional action understanding was significantly related to their age at Time 1, $r(112) = .41$, $p < .001$.

Infants also showed age-appropriate joint attention performance. On average, infants followed the experimenter’s gaze on half of trials ($M = 0.50$, $SD = 0.41$) and followed the experimenter’s point on just over half of trials ($M = 0.57$, $SD = 0.40$), resulting in an overall RJA mean of 0.54 ($SD = 0.36$). Infants' gaze-follow and point-follow performance was significantly correlated, $r(112) = .54$, $p < .001$. The vast majority of infants also showed some initiation of joint attention (81%). For most infants (63%), IJA attempts were limited to the use of gaze alternation. However, 18% of infants also used behaviors (shows, points, and/or reaches) to initiate joint attention. Infants' IJA gaze alternation and IJA behavior scores were significantly correlated, $r(111) = .19$, $p = .046$. The average IJA score was 2.92 ($SD = 2.96$). Both RJA scores, $r(111) = .36$, $p < .001$, and IJA scores, $r(110) = .25$, $p = .008$, were significantly related to infants' age at Time 1.

Finally, at Time 1, infants' intention understanding scores were positively related to their RJA scores, $r(109) = .31$, $p = .001$. Correlations between all other Time 1 variables (intention understanding and IJA; RJA and IJA) were non-significant (see Table 1).

Time 2 Descriptives—On average, parents reported solid levels of theory of mind knowledge in their children at Time 2. The mean overall CSUS score of 3.06 ($SD = 0.43$) is equivalent to parents endorsing the scale items at the level of "somewhat true". In this relatively age-restricted sample (37 to 45 months), children's age did not correlate with overall CSUS scores, $r(114) = .11$, $p = .23$).

Initial Correlations across Time 1 and Time 2—One significant correlation across the Time 1 and Time 2 measures was observed (see Table 1): IJA at Time 1 was positively related to preschoolers' CSUS scores, $r(112) = .27$, $p = .005$. The correlations between preschoolers' CSUS scores and both intentional action understanding and RJA at Time 1 did not reach significance (both ps > .53).

Path Model

The focal path model with direct paths from Time 1 intentional action understanding, RJA, and IJA to Time 2 CSUS is shown in Figure 1 (CFI = 1.00, RMSEA < .001 [90% CI: .00, .10], SRMR = .024). Results showed that children's average CSUS score at Time 2 was predicted by IJA at Time 1: Infants who produced more attempts to engage the experimenter in joint attention at Time 1 showed better parent-reported theory of mind as preschoolers at Time 2. The longitudinal paths from intentional action understanding and RJA to CSUS scores were non-significant. Although the covariates are not depicted in Figure 1, Time 1 age predicted intentional action understanding ($\beta = .38$, $p < .001$), IJA ($\beta = .27$, $p = .001$), and RJA ($\beta = .33$, $p < .001$), and participant gender predicted intentional action understanding ($\beta = .24$, $p = .004$) and RJA ($\beta = .24$, $p = .005$). No other paths involving covariates reached significance.

Discussion

The goal of the current study was to extend the growing literature establishing longitudinal associations between key social-cognitive capacities emerging in infancy and children's subsequent theory of mind. We recruited a large sample of infants enabling a properly powered investigation, examined multiple measures of social cognition in the same infants at Time 1 (intentional action understanding, RJA, IJA), and used a theory of mind assessment at Time 2 that was uniquely designed to capture variability in preschoolers' mental state understanding (the CSUS; Tahiroglu et al., 2014). Results revealed a significant longitudinal association between infant IJA at 8 to 12 months and theory of mind at age 3. In contrast, the paths from RJA and intentional action understanding to later theory of mind, did not emerge as significant. In the sections below, we consider each of these findings and how they shed light on the origins of theory of mind.

Initiating Joint Attention (IJA)

The central longitudinal pathway that emerged as significant in the current study was the pathway from initiating joint attention (IJA) in infancy to later theory of mind. Specifically, middle-class American infants who were more likely to engage in attempts to initiate joint attention with an unfamiliar experimenter through gaze alternation or gestures such as showing, pointing, or reaching, went on to show better parent-reported mental state understanding as preschoolers. This finding is consistent with existing work recognizing the contribution of early IJA to various developmental outcomes, including language (Malesa et al., 2013; Mundy et al., 2007), prosocial behavior (Stout et al., 2021), social competence (Van Hecke et al., 2007), and, most focally, theory of mind (Charman et al., 2000; Sodian & Kristen-Antonow, 2015). In particular, the current findings parallel evidence of longitudinal associations between preschoolers' observed theory of mind and isolated measures such as communicative gaze shifts at 20 months of age (Charman et al., 2000) and pointing to convey information at 12 months (Sodian & Kristen, 2015). Importantly, our data extend this literature by revealing for the first time that individual differences in the broader construct of IJA present as early as 8 months of age predict later theory of mind.

There are several possible explanations for why IJA predicted later theory of mind. One possibility is that infants' IJA behaviors reflect a form of early mental state knowledge that may be continuous with or lay the conceptual foundation for later theory of mind (e.g., Bretherton, 1991; Tomasello, 1995; Wellman, 2014). The knowledge most commonly attributed to infants based on joint attention behaviors is an understanding of others as intentional agents who act on and selectively attend to their environment (Tomasello, 1995). Thus, it may be that the understanding of intentionality that is manifest in infants' IJA behaviors provides the foundation for later mental state concepts. Although this interpretation remains plausible, given that we found IJA was unrelated to intentional action understanding and intentional action understanding was unrelated to later theory of mind (see below for further discussion), our findings do not directly support this hypothesis.

Another interpretation is that rather than reflecting early mental state understanding, the experience of engaging in joint attention in infancy provides fertile ground for learning about others' mental states (e.g., Barresi & Moore, 1996; Carpendale & Lewis, 2004; Liszkowski, 2013; Mundy & Newell, 2007; Tomasello, 2018). In particular, through repeated practice coordinating action and attention with social partners in joint attention, infants may be better able to gain insight into the mental states of others (see Brandone et al., 2020 for related evidence in infancy). According to this account, infants who show stronger IJA behavior should have greater opportunities to accumulate the kinds of experiences necessary to promote their developing theory of mind. The theory of mind advantage revealed in the current study for preschoolers who as infants showed more spontaneous, volitional attempts to engage others in joint attention provides clear support for this interpretation.

A related possibility is that the relation between infants' IJA and later theory of mind is an indirect one that is mediated by other important developmental outcomes. Given the communicative function of IJA, one plausible mediator is language. Research has supported clear links between early IJA and later language skills (e.g., Charman et al., 2000; Malesa et al., 2013; Mundy et al., 2007). Moreover, language ability is a well-established predictor of theory of mind (Milligan et al., 2007) and has been argued to play a causal role in its development by providing opportunities for participation in communicative exchanges and access to mental state concepts that are critical to developing a theory of mind (Astington & Baird, 2005). Thus, early IJA may contribute to the development of theory of mind by setting the stage for the development of language abilities.

Finally, it remains possible that both infant IJA and preschoolers' theory of mind reflect variability in a third factor that shows relative stability from infancy to early childhood. For example, stable trait-like differences in the motivation to share experiences and communicate with others (e.g., Mundy & Acra, 2006) could manifest in both more IJA in infancy and better mental state reasoning in early childhood. This may be particularly likely given the parent-report nature of our theory of mind measure: parents of children who are dispositionally more inclined to share attention and experiences with others may be more likely to notice their children's social-cognitive abilities during infancy and early childhood and thus better able to report on those abilities in the CSUS. Alternatively, emerging executive function abilities may underlie variability in both early IJA (see Miller & Marcovitch, 2015; Mundy & Newall, 2007; Van Hecke et al., 2007 for related evidence and arguments) and later theory of mind (e.g., Carlson & Moses, 2001; Devine & Hughes, 2014). A critical goal for future research will be to differentiate among these various explanations in order to understand the precise role early IJA plays in the development of theory of mind.

Responding to Joint Attention (RJA)

The contribution to later theory of mind of the other type of joint attention observed in the current study, responding to joint attention (RJA), was less clear. Specifically, we failed to detect a significant pathway from middle-class infants' gaze and point following behavior to their later theory of mind.

On one hand, it is not particularly surprising that RJA and IJA showed different patterns of relations with later theory of mind. The differences between RJA and IJA, including their differential prediction of developmental outcomes, are well established in the literature (see Mundy, 2016, for a review). One difference that may be particularly relevant here is that RJA has been argued to engage more reflexive or obligatory attentional processes whereas IJA is thought to involve more volitional and goal-directed processes (Mundy & Jarrold, 2010). In other words, as Mundy and Jarrold (2010) write, we are "compelled" to follow others' attention, but we "choose" to initiate joint attention to share experience with others (p. 988).

These distinguishing features may also explain RJA and IJA's differential relations with later theory of mind. For example, RJA's more reflexive nature may mean that it serves as a less powerful predictor than IJA of participation in the kinds of joint-attentive interactions that have been hypothesized to promote the development of mental state understanding (e.g., Barresi & Moore, 1996; Carpendale & Lewis, 2004). Similarly, on the hypothesis that a stable, trait-like motivation to communicate and share with others (e.g., Mundy & Acra, 2006) underlies variability in both joint attention and theory of mind, RJA behaviors (which tend to be subtle and obligatory) may provide a weaker signal of this motivational quality than IJA behaviors (which are more salient and effortful).

Despite these arguments in defense of the null association between RJA and later mental state understanding, it is important to recognize that the literature does include some support for links between early RJA and later mental state understanding. In particular, children's use of mental state language at age 2–3 years was predicted by gaze following (Brooks & Meltzoff, 2015) and point following (Kristen et al., 2011) in the first year of life. That is, infants who more successfully followed the attention of others went on to show a richer parent-reported vocabulary of mental state terms. Notably, Brooks and Meltzoff (2015) also tested but did not find support for a direct link between infant gaze following and theory of mind task performance at age 4.5 years. Thus, it may be that the contribution to theory of mind development of RJA is more indirect and perhaps mediated through children's acquisition of mental state language or language more generally. More comprehensive longitudinal work assessing early social cognition at more than two timepoints may help shed further light on the distinct roles of RJA and IJA in theory of mind development.

Intentional Action Understanding

A third noteworthy finding from the current study is that middle-class American infants' intentional action understanding did not emerge as a significant predictor of later theory of mind. This finding stands in contrast with several studies showing continuity between intentional action processing in infancy and theory of mind in the preschool years (Aschersleben et al., 2008; Sodian et al., 2016; Wellman et al., 2004; 2008; Yamaguchi et al., 2009; see also Poulin-Dubois et al., 2020 for similar null findings). There are important differences between the measure of intentional action understanding implemented in the current study and those used in prior longitudinal studies that may explain these discrepant findings. For example, in the present study, we used an anticipatory-looking paradigm to measure infants' online processing rather than a looking-time paradigm and we assessed infants' understanding of a failed intentional action (i.e., reaching for but failing to grasp a ball), specifically. Although the tasks used in the prior longitudinal studies varied considerably, none involved anticipatory looking or a failed action. The current study is also unique in its use of a parent-report measure of mental state reasoning as opposed to behavioral theory of mind tasks. Each of these methodological decisions was made deliberately, namely to provide a more rigorous assessment of intentional action understanding in infants and to capture greater variability in mental state reasoning in preschoolers; however, these decisions may have impacted our ability to detect an effect of intention understanding.

Nevertheless, we argue that there are reasons to be skeptical about the longitudinal path from infants' intentional action understanding to later theory of mind reasoning. As noted in the introduction, most prior studies exploring these longitudinal relations have used modest sample sizes and have had limited statistical power, which can increase the likelihood that statistically significant findings are spurious (Button et al., 2013). Prior findings have also been inconsistent upon close scrutiny, including discrepancies in which measures (decrement of attention versus test event preferences) show significant associations and in the direction of the effects observed (e.g., Aschersleben et al., 2008; Wellman et al., 2004, 2008). In a recent study using neurophysiological measures in order to better understand the cognitive processes underlying continuity between early action processing and later theory of mind, Filippi and colleagues (2020) showed that infants who more efficiently recruited their attentional system while processing the goal-directedness of a human action went on to show better theory of mind as 3-year-olds. Notably, Filippi et al. did not find evidence that the neural processes that support the encoding of goal-directedness itself (in the sensorimotor system) predicted later theory of mind.

Thus, overall, we argue that the existing findings on the association between theory of mind and early intentional action processing—including the null results presented here—tentatively suggest that theory of mind development may have its roots in how infants attend to but not necessarily how well they understand intentional actions (see also Brink et al., 2015). This focus on how infants recruit attention during social events or interactions is broadly aligned with the hypothesis described earlier that infants' experience engaging in joint attention with social partners informs their developing mental state understanding (e.g., Mundy, 2016). Of course, additional research is needed to more directly test these ideas and to better understand the mechanisms explaining the longitudinal relations between infants' attention to intentional actions and their subsequent theory of mind development.

Interrelations among the Measures of Infant Social Cognition

Finally, although not the primary focus of the current investigation, our data also speak to questions about the interrelatedness of different social-cognitive constructs in infancy. We observed minimal associations among the measures of infant social cognition at Time 1. Specifically, we found that infants' intentional action understanding was moderately positively related to their RJA. However, we did not observe significant associations between intention understanding and IJA, or between the two subtypes of joint attention. In addition, none of the associations among the Time 1 variables reached significance in the path model including Time 1 age and child gender as covariates.

This largely null pattern of results may be considered surprising if joint attention is conceptualized as a unitary construct that rests on an underlying understanding of the intentionality of others (see Tomasello, 1995). However, support for such a perspective has been limited. Indeed, consistent with the current findings, several studies have documented modest to non-significant concurrent relations among joint attention behaviors during infancy (e.g., Mundy et al., 2007; Sheinkopf et al., 2004; Slaughter & McConnell, 2003). For example, in a longitudinal investigation of individual differences in the development of joint attention, Mundy et al. (2007) observed no significant concurrent associations between IJA and RJA at 9, 12, 15, or 18 months. Together with evidence suggesting that IJA and RJA show different developmental trajectories (Mundy et al., 2007), are supported by different patterns of brain activity (Mundy et al., 2000; Redcay et al., 2012), involve different attentional and motivational processes (Mundy & Jarrold, 2010), and differentially predict later developmental outcomes (e.g., Mundy et al., 2007; Stout et al., 2021; Van Hecke et al., 2007), these findings reiterate the uniqueness of the different subtypes of joint attention in infancy (see Mundy, 2016 for a theoretical account).

If we expand our focus to also consider infants' intention understanding, there is some support in the prior literature for associations between joint attention and intentional action understanding (Brandone et al, 2020; Brune & Woodward, 2007; Dunphy-Lelii et al., 2014). For example, Dunphy-Lelii et al. (2014) found that 10–12-month-olds who were faster to habituate to an intentional action display showed higher concurrent levels of joint attention (as assessed through joint engagement, gaze following, and turn-taking with a parent during play), providing support for an association between intention understanding and RJA that is similar to that observed in the current study. Dunphy-Lelii et al. also reported that infants characterized as having a more socially attentive temperament (assessed in part through the use of pointing and showing behaviors with their parent) habituated faster to an intentional action display, providing some indirect support for an association between intention understanding and IJA.

It is not clear why the current study showed links between intention understanding and RJA but not IJA. This may be because both the gaze/point-following tasks and the failed action understanding task involve reacting to the observed behavior of others and require a process of attention shifting (i.e., from the actor's face to the actor's focus of attention in the case of gaze/point following, and from the actor's reaching motion to the goal of the actor's reach in the case of intentional action understanding). These reactive processes may be distinct from the more volitional processes involved in initiating joint attention with a social partner (Mundy & Jarrold, 2010). More work is needed to unpack how intention understanding and different forms of joint attention are interrelated in infancy. However, it seems likely that although intentional action understanding, RJA, and IJA rest on partially overlapping social-cognitive processes, they are nonetheless unique constructs that play distinct roles in early social-cognitive development (see Mundy, 2016 for further discussion).

Limitations and Future Directions

Although the current study has many strengths, including its longitudinal design, large sample size, and the thorough nature of our infant social cognition measures, there are also some important limitations. Most notably, in contrast to our comprehensive Time 1 data, our Time 2 data were more limited. In particular, a significant limitation is that the current study did not involve behavioral measures of theory of mind, such as the false belief task (Wimmer & Perner, 1983) or the Theory of Mind Scale (Wellman & Liu, 2004). The parent-report measure used here has been demonstrated to be a valid assessment of theory of mind and has some clear advantages over behavioral tasks, including its sensitivity to individual differences, ecological validity, capacity to provide a more global assessment of mental state reasoning across multiple domains, and psychometric properties that are as high or higher than standard laboratory tasks (see Tahiroglu et al., 2014); however, there may be limitations to relying on parents alone as informants. For example, parents may vary in their insight into their children's mental state reasoning, their motivation in responding, and/or their tendency to read into or exaggerate their children's abilities. Parents' responses on the CSUS may also be influenced by factors adjacent to their children's theory of mind abilities, such as language or overall sociability. Parents' ability to notice and report on their children's mental state reasoning may even be impacted by children's joint attention behaviors, helping to explain the relation between IJA and theory of mind observed here. Thus, while we chose to use the parent-report Children's Social Understanding Scale for its ease of use, ecological validity, and sensitivity to individual differences, supplementing it with behavioral measures of theory of mind in future work would provide a more complete assessment of children's mental state reasoning.

Another major limitation of the current study is the fact that we did not include measures of other cognitive abilities at Time 2, including those known to be associated with theory of mind in preschoolers, such as language (e.g., Milligan et al., 2007) and executive function (e.g., Carlson & Moses, 2001; Devine & Hughes, 2014). Given the specificity of the paths from Time 1 infant social cognition to Time 2 theory of mind, it is unlikely that the continuity we observed is driven by cognitive maturity alone. If it were simply the case that more advanced infants developed into more advanced preschoolers, we would expect to see significant paths from all of the Time 1 measures to Time 2 theory of mind. That a significant path emerged for Time 1 IJA only casts doubt on this possibility. It is also unlikely that parent-reports of children's mental state understanding on the CSUS were just a proxy for capacities such as language or executive function, given only modest correlations among these variables and CSUS scores in prior work (Gluck et al., 2020; Tahiroglu et al., 2014). Nevertheless, given the number of intriguing mechanisms explaining the path from infant IJA to preschool theory of mind (e.g., whether the path is a direct one, whether it is mediated by later language development, whether it is driven by executive function or sociability), additional systematic work is needed to understand precisely how social cognition, language, and executive function work together across development.

In sum, the findings from the current longitudinal investigation add to the growing literature suggesting that mental state reasoning is rooted in foundational social-cognitive capacities emerging in infancy. Our results highlight the role of early joint attention in later mental state reasoning—in particular, the more active and volitional subtype of joint attention (IJA). Our data also help to clarify the role of early intentional action processing in later theory of mind, tentatively suggesting that it may be infants' attention to people and their intentional actions (rather than infants' understanding of these actions) that is influential for theory of mind development. An important goal for future work will be to replicate these findings using observed measures of theory of mind and to further unpack how social attention and behavior work together with cognitive capacities such as language and executive function across infancy and early childhood to support the development of an understanding of the mind.

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Data Availability Statement

The data described in this article are openly available in the Open Science Framework at https://osf.io/xfkyv

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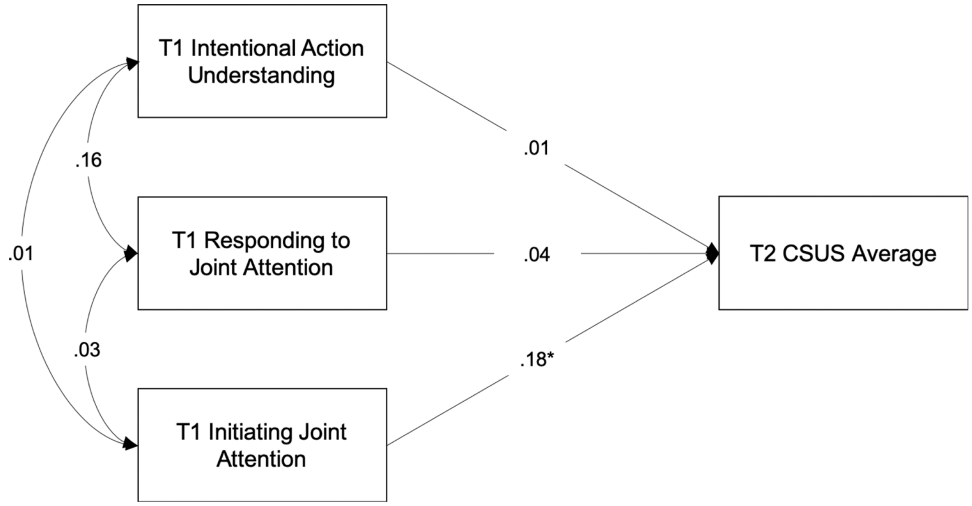

Figure 1.
Longitudinal path model showing standardized path coefficients from Time 1 social-cognitive capacities (intentional action understanding, responding to joint attention, initiating joint attention) to Time 2 scores on the Children's Social Understanding Scale. For simplicity, covariates at Time 1 (infant age, gender) and Time 2 (child age, gender) are not depicted. * $p = .022$.

Table 1

Descriptive statistics (observed range, mean, standard deviation) and nonparametric correlation coefficients (Spearman's rho) for the Time 1 measures of infant social cognition and Time 2 theory of mind

Variable	Range	M	SD	1	2	3	4
1. T1 Intention Understanding	0.0–2.0[a]	0.94	0.66	--			
2. T1 RJA	0.0–1.0[b]	0.54	0.35	.31**	--		
3. T1 IJA	0.0–18.0[c]	2.92	2.96	.07	.05	--	
4. T2 CSUS Average	1.4–3.7[d]	3.06	0.43	.03	.06	.27**	--

Note.

** $p < .01$.

Possible range:

[a] 0.0–2.0,

[b] 0.0–1.0,

[c] 0.0 – no max value,

[d] 1.0–4.0.