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Think fast! The relationship between goal prediction speed and social competence in infants

Sheila Krogh-Jespersen, **Zoe Liberman**, and **Amanda L. Woodward**
Department of Psychology, University of Chicago, USA

Abstract

Skilled social interactions require knowledge about others' intentions and the ability to implement this knowledge in real-time to generate appropriate responses to one's partner. Young infants demonstrate an understanding of other people's intentions (e.g. Woodward, Sommerville, Gerson, Henderson & Buresh, 2009), yet it is not until the second year that infants seem to master the real-time implementation of their knowledge during social interactions (e.g. Warneken & Tomasello, 2007). The current study investigates the possibility that developments in social competence during the second year are related to increases in the speed with which infants can employ their understanding of others' intentions. Twenty- to 22-month-old infants (N = 23) viewed videos of goal-directed actions on a Tobii eye-tracker and then engaged in an interactive perspective-taking task. Infants who quickly and accurately anticipated another person's future behavior in the eye-tracking task were more successful at taking their partner's perspective in the social interaction. Success on the perspective-taking task was specifically related to the ability to correctly predict another person's intentions. These findings highlight the importance of not only being a 'smart' social partner but also a 'fast' social thinker.

Introduction

To interact in socially smart ways, infants have to infer their partner's likely intentions and states of attention and accomplish this rapidly enough to generate a well-organized social response. Converging evidence from passive methods, such as visual habituation, suggests that preverbal infants have a conceptual understanding of others' intentions (e.g. Brandone & Wellman, 2009; Luo & Johnson, 2009; Skerry, Carey & Spelke, 2013; Sodian & Thoermer, 2004; Woodward, Sommerville, Gerson, Henderson & Buresh, 2009); yet, infants do not appear as sophisticated in their real-time implementation of this knowledge during naturalistic interactions until well into their second year (e.g. Brownell & Carriger, 1990; Carpenter, Call & Tomasello, 2005; Hunnius, Bekkering & Cillessen, 2009; Repacholi & Gopnik, 1997; Warneken & Tomasello, 2007). Why might infants look 'smart' in passive experimental tasks that measure social knowledge, and yet look substantially less 'smart' in their overt social behaviors? The current study investigates the possibility that developments in social competence during infants' second year are driven by increases in

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Address for correspondence: Sheila Krogh-Jespersen, Department of Psychology, University of Chicago, Chicago, IL 60637, USA; skrogh@uchicago.edu.

their real-time implementation abilities: infants may become faster at deploying their understanding of others' intentions.

Recent eye-tracking studies have provided a window into infants' rapid, on-line responses to others' actions. When infants watch actions such as a hand reaching toward an object or moving an object into a container, they visually anticipate the endpoint of the action– that is, they look to the endpoint before the hand reaches it (e.g. Brandone, Horwitz, Wellman & Aslin, 2014; Falck-Ytter, Gredebäck & von Hofsten, 2006; Gredebäck, Stasiewicz, Falck-Ytter, Rosander & von Hofsten, 2009; Henrichs, Elsner, Elsner, Wilkinson & Gredebäck, 2013). Further, infants anticipate familiar movements with objects, for example, anticipating that when a person lifts a cup, she will move it to her mouth (Hunnius & Bekkering, 2010). These rapid, appropriate visual responses to others' actions are sometimes assumed to involve an understanding of the actor's goal, but it is also possible that they rely on other information, for example, familiar movement regularities and the trajectory information that is present in a completed action.

To seek clearer evidence as to whether infants can use goal information to generate rapid action predictions, Cannon and Woodward (2012) developed an eye-tracking measure of infants' on-line goal predictions based on the logic that has been used in prior habituation studies (e.g. Woodward, 1998). Infants saw a familiarization event in which a hand reached for and grasped one of two objects. During test trials, the objects' positions were reversed, such that the previous goal object was now in a new location. The hand began to reach but paused between the two objects. Infants looked predictively to the prior goal object, rather than the prior location, suggesting that they used information about the action goal to inform their predictions on test trials. Krogh-Jespersen and Woodward (2014) followed up on this result by investigating the time course of 15-month-old infants' goal- versus location-based predictions and found that goal-based predictions occurred with longer latencies than location-based predictions, suggesting that using information about others' goals to make on-line predictions is cognitively challenging for infants at this age.

These results highlight the potential importance of the latency to engage in intention understanding as a gate on infants' emerging abilities in active social tasks. One possibility is that the increasing social competence that emerges during the second year reflects, at least in part, improvements in the ability to recruit conceptual knowledge in order to respond quickly and appropriately to others' actions. In other words, infants' understanding of other people's goals and intentions may be present early in development, but it may take time to improve on the rapid implementation of this understanding. In this case, individual variations in how quickly infants can process information about others' intentions should predict infants' emerging social competence during real-time interactions: infants who are fast and accurate when thinking about other people's goals should be better at implementing their social knowledge in their interactions with other people. In the current study, we used the paradigm developed in Krogh-Jespersen and Woodward (2014) as a measure of the speed with which infants could recruit their knowledge of another person's intentions. We will refer to this construct as Goal Prediction Speed (GPS). Thus, we evaluated whether the speed with which infants analyze others' intentions was related to social competence by studying the relationship between infants' GPS and their performance in a social competence task that required perspective-taking.

By the start of their second year, infants develop key components of perspective-taking according to passive looking-time measures (e.g. Caron, Kiel, Dayton & Butler, 2002; Dunphy-Lelii & Wellman, 2004; Luo & Baillargeon, 2007; Sodian, Thoermer & Metz, 2007); however, during interactive situations that involve active participation, perspective-taking appears to be quite difficult and may not fully develop until later in the second year (e.g. Buttelmann, Carpenter & Tomasello, 2009; Moll & Tomasello, 2006). Because of this, we tested 20-month-old infants, a group of infants who are likely to demonstrate variable abilities in this type of interactive perspective-taking.

We designed our perspective-taking task to evaluate the aspects of social competence that may be related to Goal Prediction Speed. Specifically, GPS should be related to social competence measures that require an analysis of another person's intentions, not merely measures that require being socially responsive and engaged. Thus, in our perspective-taking task, some trials required intention understanding and others did not. In each trial, an experimenter, who could only see one of two toys, requested the toy that she could see and infants were able to reach to either toy in the set. On Different Toy Trials, the set of toys consisted of two different objects, whereas on Identical Toy Trials, both toys in the set were identical. The Identical Toy Trials required infants to analyze the experimenter's intentions by taking her perspective to respond appropriately. In contrast, the Different Toy Trials required infants to pay attention to the experimenter and to understand that they should respond to her request by selecting a toy, but being successful on these trials did not necessarily require infants to analyze the experimenter's intentions. For instance, infants could solve this task by relying on their vocabulary to choose the toy named by the experimenter. Thus, if Goal Prediction Speed is specifically related to quickly and accurately analyzing another person's intentions, then infants' GPS should be related to their performance on the Identical Toy Trials, but not necessarily to their performance on the Different Toy Trials. Because real-time social interactions require infants to rapidly implement their social knowledge, we hypothesized that infants who quickly produced accurate goal-based predictions in the eye-tracking task would also be more likely to succeed in judging another person's visual perspective in the active social task.

Method

Participants

Twenty-three 20- to 22-month-old infants (13 male) participated in the current study (*M* = 21;21, range: 20;25–22;08 months). All infants were full-term. Participants were recruited from an urban population and were 57% Caucasian, 22% African American, 13% Hispanic, and 8% Asian. An additional 14 infants were tested and excluded from further analysis due to insufficient eye-tracking data (below 50%) (11), producing predictive fixations with latencies more than 2 standard deviations from the mean (1), and failure to complete the perspective-taking task (2).

Procedure

Goal Prediction Speed measure—Participants viewed videos presented on a 24-inch monitor equipped with a Tobii T60XL corneal reflection eye-tracking system, with a sampling rate of 60 Hz. Infants were seated on their parent's lap at an approximate distance of 65 cm from the monitor. Calibration was performed with a 9-point procedure. Data were collected and analyzed using Tobii Studio (Tobii Technology, Sweden). The videos had no audio soundtrack.

First, infants watched a female actor demonstrate that she could reach for a single toy (a novel object) on either side of a table. Next, infants viewed a familiarization video in which the female actor reached for and grasped one of two toys (see Figure 1). A single familiarization trial was deemed appropriate for this study given that previous studies have found this to be adequate for supporting goal-based predictions in infants younger than those in the current study (e.g. Krogh-Jespersen & Woodward, 2014; Paulus, 2011). The target object (giraffe vs. bear), the hand the actor used (right vs. left), and the side (right vs. left) on which the target sat were counterbalanced. The timing of the action was controlled such that the actor looked at the camera (1 sec), looked down at her hand (.5 sec), raised her hand (1 sec), performed the grasping action (2.5 sec), and held the final resting position (2.5 sec). These timings are consistent with the natural timing for this event sequence.

During two identical test trials, the objects were shown in reversed locations from their positions in the familiarization video, and the actor did not complete her grasping behavior; rather, her hand paused in mid-air centered with her body and between the two toys (see Figure 1). During these test trials, the actor did not contact or look at either toy. The timing of the action in the test trials was as follows: the actor looked at the camera (1 sec), looked down at her hand (.5 sec), raised her hand (1 sec), and held her hand centered between the two objects (5 sec).

Infants' gaze fixations were identified using Tobii Studio. Areas of Interest (AOIs) were generated for the actor's hand and face, and for each of the two toys (see Figure 1). The Hand AOI was defined to encompass the space that the hand moved through during the test trials, which was an upward motion centered between the two objects. The AOIs for the objects were drawn to be identical sizes and located equally distant from the Hand AOI during the test trials. Predictive looking was defined as a fixation to the actor's Hand AOI followed by a fixation to either the goal object AOI (e.g. the object that the actor acted upon during the familiarization trial) or the location to which she had previously reached (i.e. the previously unreferenced object AOI). Responses were only counted if infants fixated in the Hand AOI and then in one of the two object AOIs. Prediction speeds were measured as the latency (in seconds) from the start of the test trial to the time that infants made a predictive fixation to the either the prior goal (Goal Prediction Speed, GPS) or the prior location (Location Prediction Speed, LPS). The average percentage of fixation data collected was 75.9%.

Perspective-taking measure—Following the eye-tracking procedure, infants were given a short break during which time they were seated across from an experimenter (E1) at a table. This break was utilized to familiarize infants with the 18 toys that would be used in the perspective-taking task. E1 presented the toys in sets of three, and infants were encouraged to play with the toys until they lost interest. When this occurred, E1 presented the next set of toys until all 18 toys had been presented. Parents were asked to interact with their infants normally during this familiarization phase, typically by either letting their infant explore on their own or helping them interact with the toys. This familiarization phase lasted approximately 5 minutes. Parents were also given a vocabulary checklist that listed the names of the 18 toys presented during the perspective-taking measure and asked to indicate which of the words their infants understood. Vocabulary levels were near ceiling, with infants recognizing an average of 16.0 (*SD* = .53) words.

After the familiarization phase concluded, a second experimenter introduced the rules of the perspective-taking game to the parents, who were asked to sit with their infants centered at the table and to hold them until E1 had completed her requests for the toys. To familiarize infants with reaching to both sides of the table, they completed four single object reaching trials. In these trials, E2 placed a toy at one end of the table, and then E1 placed her hand on the table and asked infants to give her the toy (i.e. ‘Can I have it?’). The side of the first reach was counterbalanced across infants and the subsequent reaching trials alternated sides. Following this, E1 hid behind a curtain while E2 placed a barrier on the table (see Figure 2). This barrier prevented E1 from being able to see what was on one side of the table from her position, while infants maintained visual access to both sides of the table. The side of the barrier was counterbalanced across infants.

While E1 was behind the curtain, E2 placed two toys on the table, equidistant from the infant such that both E1 and the infant could see one toy, while the other toy was placed behind the barrier such that the infant could see it but E1 could not. Then, E1 emerged from behind the curtain and asked the infant to hand her the toy that was in her view by saying, for example ‘Oh, a car. I see the car. Can you give me the car?’ and placing her hand palm-up on the table. E1 always requested the toy that she had visual access to. E1 did not provide any visual cues about which toy she was requesting: she instead kept her gaze centered throughout the trial, looking either at the infant or her own hand.

Across 12 trials, half of the trials were Different Toy Trials, which featured two different toys (e.g. an apple and a set of keys) and half of the trials were Identical Toy Trials, which featured two identical toys (e.g. two cars). E2 recorded which toy the infant reached to first after hearing E1’s requests. The Different Toy Trials served as a control: they could be solved using vocabulary knowledge and therefore did not require active understanding of E1’s intentions. Thus, correct responses on the Different Toy Trials could reflect infants’ general social engagement with the task or their interest in responding appropriately to E1’s requests. However, in order to correctly reach for the seen toy during the Identical Toy Trials, infants had to consider E1’s visual perspective to infer the intended meaning of her utterance. Thus, performance on the Identical Toy Trials requires active perspective-taking and intention understanding.

To code infants’ choices during the behavioral task, E2 recorded which toy the infant reached to first on each trial. For every trial, infants could reach to the seen object, the hidden object, both objects simultaneously or neither object.[1] All trials were coded by E2 and by a reliability coder who watched the video of each session, and agreement regarding infants' responses was 100%. On the Different Toy Trials, reaching to the seen object is the unambiguous correct response. However, on the critical Identical Toy Trials, which require perspective-taking, there are two ways to consider correct responses. Reaching to both toys is correct in that the infant gives E1 the toy she asks for in addition to another version of the same toy. However, reaching to both toys is also incorrect given that E1 requested a single toy, which was always the seen toy. Thus, trials in which infants responded by reaching to both objects simultaneously were ambiguous. Because of their ambiguity, trials during which infants reached to both objects were excluded.[2] Therefore, we calculated the proportion of trials in which each infant reached to the seen object over the hidden object. Each infant received two proportion scores for their responses, one for the Different Toy Trials and one for the Identical Toy Trials. While we chose this means of representing the data, the overall pattern of results is similar when reaching for both toys is considered an incorrect response and analyses are instead performed using the raw number of times each infant reaches for the seen toy in both the Different Toy and Identical Toy Trials.

Results and discussion

For the eye-tracking measure, infants visually predicted that the actor would reach for the prior goal in the new location at above chance rates (set at .5) on the first test trial (*M* = .74, *SD* = .46; *t*(21) = 2.34, *p* = .029), but not during the second test trial (*M* = .48, *SD* = .51; *t*(22) =−.21, *p* = .833). This response decrement may be due to the presentation of an incomplete action, as the actor's hand never contacted either object during the test trials (see Brandone *et al*., 2014, for a similar result). Although infants were not above chance on both trials, it is noteworthy that infants generated goal-based visual predictions for an incomplete action immediately after viewing the single familiarization trial. This finding replicates previous findings (Cannon & Woodward, 2012; Krogh-Jespersen & Woodward, 2014; Paulus, 2011) indicating that infants anticipate the goal-directed reaching behaviors of others. In contrast to 15-month-old infants, the 20-month-olds in this study did not differ reliably in the time required to generate prior goal predictions (*M* = 2.71 seconds, *SD* = 1.73) compared to prior location predictions (*M* = 2.51 seconds, *SD* = 1.56), *t*(36) = .34, *ns*). Interestingly, while the average GPS for the 15-month-old infants in the Krogh-Jespersen and Woodward (2014) study was 3.12 seconds, 20-month-old infants in this study made goal predictions with an average latency of 2.71 seconds. This difference in latency is consistent with the proposal that GPS would decrease with age as infants become more adept at rapidly implementing their conceptual knowledge.

For the perspective-taking task, infants performed above chance during the Different Toy Trials (*M* = 0.72, *SD* = 0.22, *t*(22) = 4.58, *p* < .001), whereas they were only marginally above chance on the Identical Toy Trials (*M* = 0.64, *SD* = 0.36, *t*(22) = 1.86, *p* = .076.).

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[1] On a small proportion of trials, infants reached to a toy before E1 had the chance to label which toy she was referring to. Because choices that happened before a label could not be based on E1's request, these trials were coded as mistrials and removed from subsequent analyses.

[2] Infants reached for both objects on an average of 1.04 trials (*SD* = 1.40) across the six Identical Toy Trials and 0.65 trials (*SD* = 1.37) across the six Different Toy Trials. This difference was significant, *t*(22) = 2.60, *p* = .016. It is reasonable that infants would reach to both toys more frequently in the Identical Toy Trials as on those trials both toys matched the name used by the experimenter.

Although infants were not systematically above chance during the Identical Toy Trials, which required active perspective-taking, their success rates were comparable to those found in previous active perspective-taking tasks conducted with infants of similar ages (e.g. Herold & Akhtar, 2008).

We used linear regressions to examine our primary question of whether individual variations in GPS were statistically predictive of infants' performances on the perspective-taking task. As participants' age and their general attention levels during the eye-tracking task (as measured in seconds attending to the on-screen stimuli) were not related to their scores on the perspective-taking task, these factors were excluded from further analyses. We conducted one regression for the perspective-taking trials that required intention understanding (the Identical Toy Trials) and one for the trials that could be solved in a number of ways (the Different Toy Trials). The proportion scores for both trial types were arcsine-square root transformed prior to being entered into the linear regressions (see Sokal & Rohlf, 1981). These regressions allow us to examine whether any influence of GPS is specific to social tasks that require infants to actively use their intention understanding.

The first regression predicted infants' perspective-taking skills (infants' scores on the Identical Toy Trials) using their speed to generate a prediction during the eye-tracking task and the type of prediction made (goal-based vs. location-based) as factors. Neither speed to generate a prediction (Wald chi-square = .61, $p = .44$) nor the type of prediction made (Wald chi-square = 2.11, $p = .15$) were significant predictors of infants' perspective-taking skills. However, the interaction of speed and prediction type was significant (Wald chi-square = 5.01, $p = .03$). Upon closer examination, this interaction was due to differences in the importance of speed based on which type of prediction was made. For correct goal-based predictions, the speed of the prediction was related to the ability to judge the experimenter's perspective: infants with faster goal-based predictions were better at taking the experimenter's perspective in the Identical Toy Trials (Wald Chi-Square = 7.01, $p = .008$; see Figure 3). On the other hand, for incorrect location-based predictions, the speed of the prediction did not significantly predict infants' perspective-taking (Wald chi-square = .78, $p = .38$).

To determine whether quickly making accurate goal-based predictions was specifically related to performance in tasks that require intention understanding and not merely to general social engagement, a second regression was conducted on infants' scores on the Different Toy Trials. This regression predicted infants' scores on the Different Toy Trials using their latency to generate a prediction during the eye-tracking task and the type of prediction made (goal-based vs. location-based) as factors. None of these factors or their interactions were significant (all *p*s > .20). Thus, these analyses indicate that GPS was exclusively related to infants' behavior during a social interaction that required intention understanding.

In a final analysis, we asked whether GPS was specifically related to infants' perspective-taking abilities or whether other types of action anticipation (e.g. when trajectory information is provided) are also reliable as predictors. To do this, we analyzed whether infants who were faster at fixating on the goal object during the familiarization event performed better in the active perspective-taking task. Movement and trajectory information was available following the 2.5 second mark of the familiarization video, and the actor's hand contacted the goal object at the 5 second mark. Infants' average latency to fixate on the goal object was 3.74 seconds (*SD* = .75), which was significantly before the actor contacted the object, *t*(22) = 8.06, *p* < .001. Thus, consistent with previous research (e.g. Gredebäck *et al*., 2009; Henrichs *et al*., 2013), infants anticipated the endpoint of the reaching action. However, a linear regression predicting infants' perspective-taking skills (infants' scores on the Identical Toy Trials) with their familiarization anticipation latency as a factor revealed no significant relationship (*B* = .22; *t*(22) = 1.04, *p* = .31). Thus, our measure of the speed with which infants implement their intention understanding reflects infants' action understanding in a manner that differs from previous measures of action anticipation. Moreover, general visual quickness (including fast action anticipation and fast location-based prediction) is not a strong predictor of infants' social competence. Instead, being able to quickly use goal information predictively is important.

General discussion

The results of the current study indicate that the speed with which infants can recruit and deploy their knowledge about others' intentions is a critical predictor of their success during a social interaction. Infants who were faster to generate goal-based predictions were also more successful during a real-time interaction that required them to consider their social partner's perspective. This relationship was specific to goal-based predictions. The speed of infants' location-based predictions was not related to their success in the perspective-taking task. Furthermore, this result was specific to success in a social interaction that required infants to consider the intentions of their social partner: GPS was not related to infants' responses to social requests that did not require perspective-taking.

Our results shed light on an apparent paradox regarding early social cognitive development: if young infants show competence in passive measures of social cognition, why do they often fail to respond appropriately on measures of overt social competence? Given that a dominant focus in developmental research is on what infants know at different points in development, researchers have not considered the question of how quickly infants can implement this knowledge. This focus has often led researchers to interpret infant behavioral data as indicators of either the presence or absence of some aspect of social knowledge – if infants respond systematically they 'have it' and if they fail to do so they 'don't have it'. The results of our study help reconcile divergent findings by suggesting that infants' failures in overt social competence are related to, and may derive from, limitations in their ability to rapidly implement their social knowledge. The current findings also highlight a number of open questions concerning infants' implementation of their social knowledge.

A first question is regarding the factors that contribute to the speed with which infants can recruit their knowledge: what makes an infant fast and accurate? One possibility is that quickly reasoning about another person's intentions may be related to general cognitive skills, such as updating working memory and accessing and using relevant information quickly. If this were the case, then domain-general developments in cognitive quickness would be predicted to drive both changes in infants' GPS and changes in their social competence during early development. Another possibility is that GPS is specifically related to and driven by expertise in managing social information when interacting with others. Further research is needed to evaluate the causal factors that underlie the observed correlation in the current study.

Our findings revealed a relation between the time required to recruit knowledge of intentions, as indexed by Goal Prediction Speed (GPS), and one measure of social competence, interactive perspective-taking. A second question is regarding how the time infants require to process other people’s intentions is related to other aspects of their active social competence. Indeed, in the second year a number of social competence abilities that require intention understanding begin to emerge, including helping, showing empathic concern, and sharing. Future research should investigate the potential role of the speed with which infants reason about intentions with regard to the emergence of these other foundational social cognitive abilities.

Given the age of the infants tested and the nature of the interactive task, the variations in the intention understanding speeds that we observed seem likely to be developmental in nature. Specifically, it is possible that infants who made faster goal-based predictions in our study were developmentally advanced compared to infants who made slower goal-based predictions. However, further research is needed to explore whether, or how, infants become faster at reasoning about intentions over the course of early development. In addition, because aspects of infant social cognition can predict long-term developmental outcomes (e.g. Aschersleben, Hofer & Jovanovic, 2008; Thoermer, Sodian, Vuori, Perst & Kristen, 2012; Wellman, Lopez-Duran, LaBounty & Hamilton, 2008), it will be important to investigate how variations in the speed with which infants can implement their intention reasoning may be related to later aspects of social cognitive development.

It is also possible that some aspects of variation in GPS reflect more enduring individual differences, such that some individuals are chronically faster at intention reasoning than others across development. Indeed, studies with older children have revealed stable cognitive biases that are linked to developmental disorders, such as conduct disorders in which hostile attribution biases may be associated with how quickly and effectively children implement their knowledge of others’ intentions during a social interaction (see Dodge, Pettit, McClaskey & Brown, 1986, for a detailed discussion). The development of the GPS measure may allow researchers and clinicians to disentangle differences in infants’ knowledge about others’ intentions from their difficulties with implementing said knowledge in a timely manner during dynamic social interactions.

The current study provides insight into infants’ developing social competence, a multidimensional ability that encompasses the social, emotional, and cognitive skills that allow infants to effectively navigate their social world. Our results provide an initial assessment of the role of speed of intention understanding in typical social development and suggest directions for future research that investigates how the time required to reason about others’ intentions changes across development, the factors that drive the ability to quickly implement knowledge of others’ intentions, and the potential role of GPS in developmental disorders that involve deficits in social cognition and social interactions, such as autism spectrum disorders and conduct disorder. Overall, social interactions occur quickly, requiring infants to recruit their knowledge of others' goals and intentions and initiate appropriate responses within a timeframe of mere seconds. Understanding how infants successfully recruit and deploy their social knowledge can inform our understanding of how we learn to navigate the complex social world.

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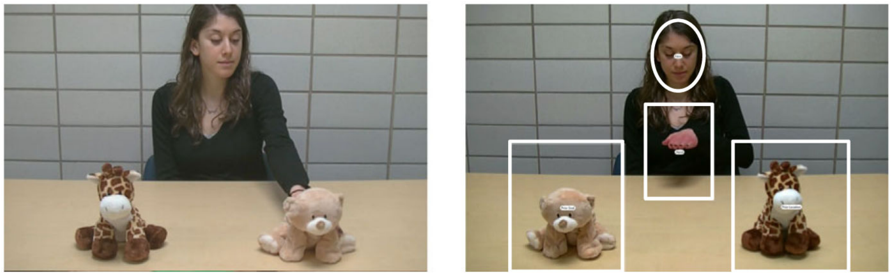
Research highlights

- Increasing social competence that emerges during the second year reflects, at least in part, improvements in the ability to respond quickly and appropriately to others' actions.
- Individual variation in infants' Goal Prediction Speed (GPS) predicted their emerging social competence during a real-time interaction.
- Infants' Goal Prediction Speed was specifically related to their ability to judge the perspective of their social partner.
- The development of the GPS measure may provide a tool for researchers and clinicians to differentiate differences in infants' knowledge about others' intentions from their difficulties with implementing their knowledge in a timely manner during dynamic social interactions.

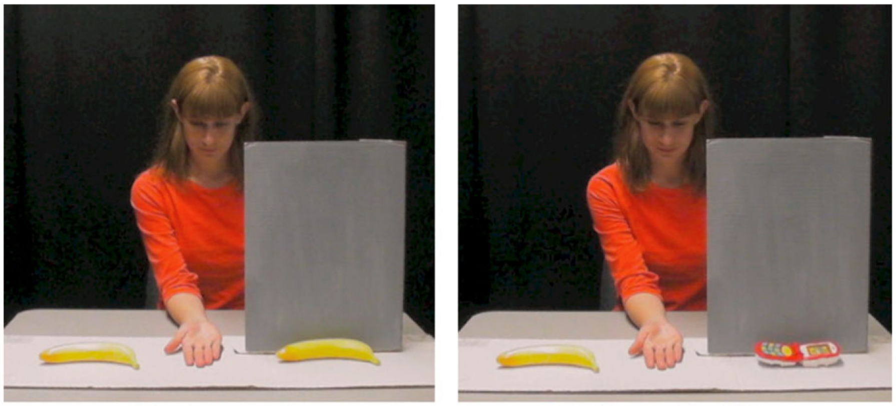


Familiarization Trial

Test Trial

Figure 1.

Depiction of the final video frames for a familiarization trial and a test trial with AOIs visible.



Identical Toy Trial

Different Toy Trial

Figure 2.

Example trials from the perspective-taking task. For each trial, infants could see two toys, while E1 could only see one toy. E1 always requested the seen toy, and E2 coded which toy infants reached to first for all trials.

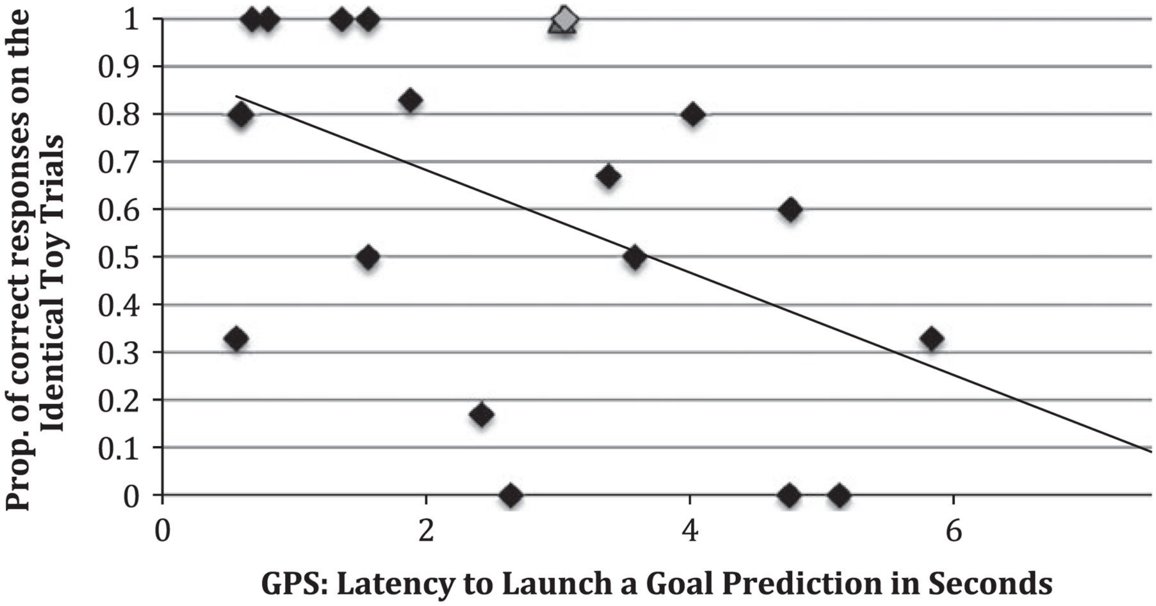


Figure 3.

Scatterplot with trend-line of infants' GPS and the proportion correct on the Identical Toy Trials during the perspective-taking task.