Chapter 1

Social Cognition at the Crossroads: Perspectives on Understanding Others

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Social cognition involves our ability to predict, monitor, and interpret the behaviors and mental states of other people. Given the importance of social cognition in interaction and survival, it is no surprise that humans have evolved to infer the meaning of others' behavior with such adeptness. As adults we can take a quick glance at other people's faces or listen only briefly to their vocal cues, and gain information that is critical to understanding their actual mental state and even their future behavior. There are also aspects of human behavior and cognition that appear unique. These behaviors include prolonged eye-to-eye contact, socially elicited smiling, and intersubjectivity or shared experience between individuals via turn taking, timing, and sharing of affect and expressions (Rochat & Striano, 1999).

With a range of new techniques we are now better able to probe the ways that humans understand others. But these new techniques have also led to some problems. Interest in social cognition from multiple disciplines since the mid-1990s has created an overall field that currently lacks cohesion. Each subdiscipline appears to be following its own path, with little reference to related issues or topics investigated in alternative ways. For instance, the majority of developmental psychologists in this field are focusing on how infants develop an understanding of others' minds. For example, they may try to determine when infants start to understand the intentions of others or they may investigate transitions in social and cognitive behavior that are presumed to relate to advances in understanding others. For the most part, paradigms utilized are entirely behavioral and are often difficult to relate to the data from other fields. Comparatively, cognitive neuroscientists are investigating complex aspects of social cognition, such as empathy processing, embodiment, and the precise role of the human mirror neuron system. Again, because of differences in methodology, sometimes these results are difficult to place in a wider context of issues, such as the role of development in complex social-cognitive skills or relations between atypical development such as autism and typical social information processing. In research on autism and related disorders, not only are the paradigms and tests developed unique to the field, but also the questions at hand are often different. In sum, if these disciplines were a trio of musicians, they might all be keeping the same beat but they would be playing different melodies.

Despite the rapid attainment of knowledge in multiple fields related to understanding others, one critical factor for further increased knowledge is the integration of multiple methodologies from different disciplines. In this chapter we will outline how integration of these techniques and perspectives can shed light on seemingly complex aspects of the human mind. Through using case examples of specific research we highlight the advances that can be made when we integrate separate fields of research.

Developing an Understanding of Others

Despite the importance of human social cognition and the behaviors that comprise it, we still know relatively little about its ontogenetic course. We argue that this is for two primary reasons. The first reason is the way that social cognition throughout development has been traditionally studied. Many researchers have focused on major transition periods that occur at around 9 and 18 months of age. In this chapter we do not deny that radical changes occur in the ways that infants and children understand other people at certain times in development. We do, however, want to point out that social cognition – understanding and relating to other people – is a protracted process that begins very early in development. A second reason for our limited understanding of the development of social cognition is that we have had limited paradigms to assess it in preverbal infants. This has been changing since the advent of the millennium. We suggest and hope to demonstrate in this chapter that an interdisciplinary research approach is necessary to understand the ontogenetic pathways that give rise to normal and also to atypical human social cognitive functioning.

The Development of Joint Attention: A Case Study of Multiple Methodologies

We briefly begin our chapter at the developmental transition, the 9-month transition, which has received so much attention and research since the mid-1990s. There is no denying that something changes by the end of the first postnatal year. By around 9 months of age, infants become much more active in some ways. They move around independently and easily coordinate their attention in triadic ways; that is, between people and objects in the world. It is almost as if the infant's need to gather information from other people directly corresponds to the ability to seek and use this information from other people. This transition is nicely summed up in the following paragraph:

> Six month old infants interact dyadically with objects, grasping and manipulating them, and they interact dyadically with other people, expressing emotions back and forth in a turn taking sequence. But at around 9 months to 12 months of age, infants begin to engage in interactions that are triadic in the sense that they involve the referential triangle of child, adult, and some outside entity to which they share attention. (Tomasello, 1999, p. 302)

There is no denying that early in development infants are more likely to engage in dyadic interactions with other people and that, later in development, these interactions become more triadic in nature (D'Entremont, Hains, & Muir, 1997; Nadel & Tremblay-Leveau, 1999). Our own research also supports this view. In one study, we had infants of 3, 6, and 9 months old interacting with an adult stranger, as is shown with the 3-month-old in Figure 1.1 (Striano & Stahl, 2005). We manipulated the social interaction between infant and adult in several ways across studies, but highlight three interactive conditions here to make our point. In one condition, the *joint-attention* condition, the adult coordinated attention between the infant and a toy by the infant's side. She did this by shifting her gaze between the infant and the toy while talking about the toy in a positive tone of voice. In another condition, the *look-away* condition, the adult looked away at the toy while vocalizing in a positive

Figure 1.1. Demonstration of triadic interaction in early development
Note: Figure shows 3-month-old following eye gaze viewed from four cameras.
Source: Striano & Stahl (2005).

way, but not by shifting her attention back and forth. We compared these conditions to a normal *dyadic* (face-to-face) interaction in which the adult talked to the infant and did not look at the object. In sum, we found that at all ages infants could discriminate among these three interactive conditions. However, the way that infants discriminated these types of interactions varied according to age. At 3 months of age, infants preferred dyadic interaction, whereas, at the older ages, infants preferred (or at least looked more at the adult during) joint-attention interactions (Striano, 2004; Striano & Stahl, 2005). Why? We think that the demands placed on the 6- and 9-month-olds are very different from demands placed on a 3-month-old. At older ages, infants are capable of manipulating objects and moving around, whereas at younger ages this is much harder without assistance (Campos & Sternberg, 1981). Simply put, triadic interactions are more useful and functional for the older infant. In the same way that we are capable of skydiving or rock climbing, but choose to fly a kite or take a walk to the local pub, the 3–5-month-old infant is highly capable of triadic interactions, although he may simply not require these for effective interaction, survival, or general satisfaction. Social interactions between infants and adults start out primarily dyadic (Stern, 1985; van Wulffen Palthe & Hopkins, 1993). This changes when the need for triadic interactions becomes more important – as infants begin to interact with unfamiliar objects and situations and as they must become sensitive to cues directed at them. But, as we will show later, this is not to imply that infants are not capable of detecting and benefiting from triadic interaction before the end of the first postnatal year. It also may be the case that the systematic use of triadic social skills does not imply any new social or cognitive understanding on the part of the infant.

Did the human infant really develop some new sort of awareness or understanding of others when he was engaging in triadic interactions? Or were triadic interactions merely a different form of social interaction? Possibly the underlying reason and drive for social interaction was the same at 9 months as it was for the infant at 3 months (see also Striano, 2004). We addressed this question in a study of 7- and 10-month-old infants. We tested infants in two phases of social interaction with an adult experimenter (Striano & Rochat, 1999). In a joint-attention phase (or triadic interaction), we measured infants' social responses on a battery of joint-attention tasks such as gaze following, point following, and social referencing. In the other phase of the study, infants participated in a still-face procedure. We expected to find that infants who scored high on triadic or joint-attention skills would use the most re-engagement attempts with the adult during the still-face procedure. For instance, when smiling did not work to re-engage the social partner, the infants might try to clap or then to vocalize to accomplish their goal. These predictions were confirmed. Infants who were engaging in the most triadic behaviors tended to be the same infants who were especially skilled in dyadic responding. This research showed that there seemed to be some link between dyadic and triadic social skills. Maybe it was not the case that the more frequent use of triadic behaviors by the end of the first year meant that infants suddenly understood their social partners differently. But the question still remained (and we think it still does): what did infants understand about the motives and intentions that guided the adult's behavior (Yazbek & D'Entremont, 2006)?

Sensitivity to Dyadic and Triadic Cues

By at least 3 months of age, infants are sensitive to the relevance of dyadic social cues directed at them, with dyadic interactions remaining the primary means of interaction with others. They become upset when communication is not directed at them (Striano, 2004) and even distinguish between an interaction that is directed at them and relevant and an interaction that is directed at them and irrelevant. When do infants become sensitive to the relevance of social cues that refer to objects and events in the world? To address this question, we had 3-, 6-, and 9-month-olds interact with a female adult (Striano & Stahl, 2005). These conditions are shown in Figure 1.2. In one condition, a *joint-attention* condition, the adult talked and smiled and alternated visual attention between the infant and an object. In an *alternating* condition, the adult coordinated visual attention but without smiling or vocalizing. In an *affect-only* condition, she looked at the infant and then up to the ceiling before looking at the object. This condition was to control for the amount of eye contact and positive affect directed toward the infant. In other words, we were controlling for the amount of social cues directed at the infant but making these cues irrelevant by inserting a break in interpersonal contact before the adult looked away at the object. In an *ignore* condition she looked only at the object while taking and providing positive affect. In this study, we found thereby that, by 3 months of age, infants already discriminated among these conditions. In fact, we found little evidence of

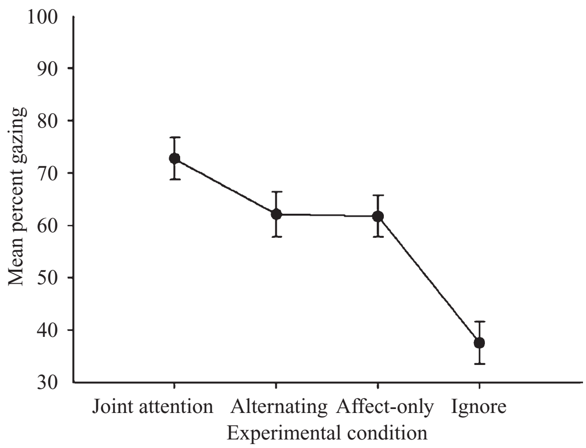

Figure 1.2. Gazing time as a function of joint-attention, alternating, affect-only, and ignore conditions

Note: Results are collapsed for 3-, 6-, and 9-month-old infants.

Source: Striano & Stahl (2005).

developmental transitions in this study. This was the first demonstration that infants could detect triadic or joint-attention interactions by 3 months of age. Just as infants are attuned to the relevance of dyadic social cues, they were also sensitive to the relevance of triadic social information. Two primary questions arose out of these findings. The first question concerned the development of this sensitivity to triadic attention, and the second question concerned the possible function of this sensitivity.

To find out when in ontogeny infants were sensitive to the relevance of triadic social cues, we tested a group of 1-month-old infants (Striano, Stahl, Cleveland, & Hoehl, 2007). In a first study, we compared infants in just two conditions, the joint-attention condition and the look-away condition. These conditions were similar to those described above with the 3-, 6-, and 9-month-olds (see Figure 1.1). One difference, however, was that these conditions were presented for a longer duration of time so that we could be sure that infants had sufficient time to detect the condition differences. In this study, we found that, even at 1 month of age, infants could discriminate between someone coordinating attention and someone just looking away and talking. Then we compared infants in the joint-attention condition and the affect condition – where the amount of social information provided was the same but the adult broke contact for a second by looking away from the infant. This time, 1-month-old infants did not discriminate between these conditions. As in the prior studies, at 1 month of age, it did not matter if this person was providing relevant or contingent, meaningful information. At 1 month, infants are likely to be sensitive to the presence of faces and social cues directed at them, but not necessarily to the more subtle cues such as timing or contingency. One possibility is that further social experience is necessary.

Beyond Detection

A sensitivity to joint attention is essential for learning. For example, it has been shown that, by 18 months of age, infants use others' gaze toward objects to learn labels (see, e.g., Baldwin, 1993; Baldwin & Moses, 1996). In order fully to benefit from joint attention, an infant must have developed an ability to integrate a number of social and cognitive skills. When do infants use triadic social cues to gain information about new things? The function of joint attention for the infant in terms of gaining knowledge about the external world remains poorly understood. Few studies have addressed the issue of how triadic interaction involving adult, infant, and object facilitates learning about objects in the surrounding world. While many studies indicate that infants modify their own behavior according to the social signals they receive, little is known about the influence of the social partner's behavior on infants' processing of the surrounding world. Some research has shown that maternal behavior during mother–infant play sessions is related to 4-month-old infants' ability to recognize and discern a familiar from a novel stimulus. Specifically, infants whose mothers were less involved during toy play (for example, vocalization, visual encouragement of attention) exhibited higher novelty preference – the type of visual preference that is associated with superior information processing (Miceli, Whitman, Borkowski, Brautgart-Rieker, & Mitchell, 1998). Itakura (2001) tested older infants (9–13-month-olds) to assess whether social and non-social events led to differential behavior on subsequent visual preference tasks. In this study, infants observed either the mother point to one of two line drawings (social event) or saw one of the line drawings blink (non-social event). In both conditions infants looked longer at the stimulus-enhanced drawing (that is, the one that was pointed at or the one that blinked). However, when the line drawings were presented again alone (without pointing or blinking), only the infants who were in the social condition showed a significant difference in their preference for the drawing that had been pointed at versus the one at which the mother had not pointed. Thus, looking behavior was influenced by the preceding social and non-social events.

In our recent research we have started to address the issue of how cues provided by adult social partners are beneficial to infants in these contexts. Recently, we examined the effects of differing social cues on object processing in 9- and 12-month-old infants (Striano, Chen, Cleveland, & Bradshaw, 2006). In a within-subject design, an adult experimenter spoke to the infants about a novel object in two conditions. In the *joint-attention* condition, the experimenter spoke to the infant about the toy while alternating gaze between the toy and the infant. The *object-only* condition was identical, except that the experimenter looked to the toy and to a spot on the ceiling, but never to the infant. In test trials, infants viewed the toy used in the social interaction along with a novel toy. Twelve-month-old infants looked to the novel toy equally following both conditions. In contrast, 9-month-olds looked to the novel toy significantly longer following the joint-attention condition relative to the object-only condition. This can be seen in Figure 1.3. These results suggest that joint-attention interactions significantly aided object processing in the 9-month-old infants (a), but not in the 12-month-old infants (b). This indicates that, by 12 months of age, infants learned about the object as long as some social cue was provided, whether it was directed only at the object (that is, object only) or both to the infant and the object (that is, joint attention). In subsequent studies, using similar paradigms (see Cleveland & Striano, 2007; Cleveland, Schug, & Striano, 2007), we were able to show that by 7 months of age infants benefited from joint-attention interactions. Learning about objects was enhanced when infants viewed novel toys in the context of a joint-attention social cue. In a series of studies, we tested infants as young as 4 months of age. We found that 4- and 5-month-old infants did not benefit from joint-attention interactions (Cleveland & Striano, 2007; Cleveland et al., 2007). This is interesting, given that, by 3 months of age, infants are already sensitive to joint-attention cues. However, when we observed their behavior in the types of paradigms described above, we found that they do not seem to learn anything more. As we will see next, however, taking a cognitive neuroscience approach and investigating event-related potentials have revealed something very different.

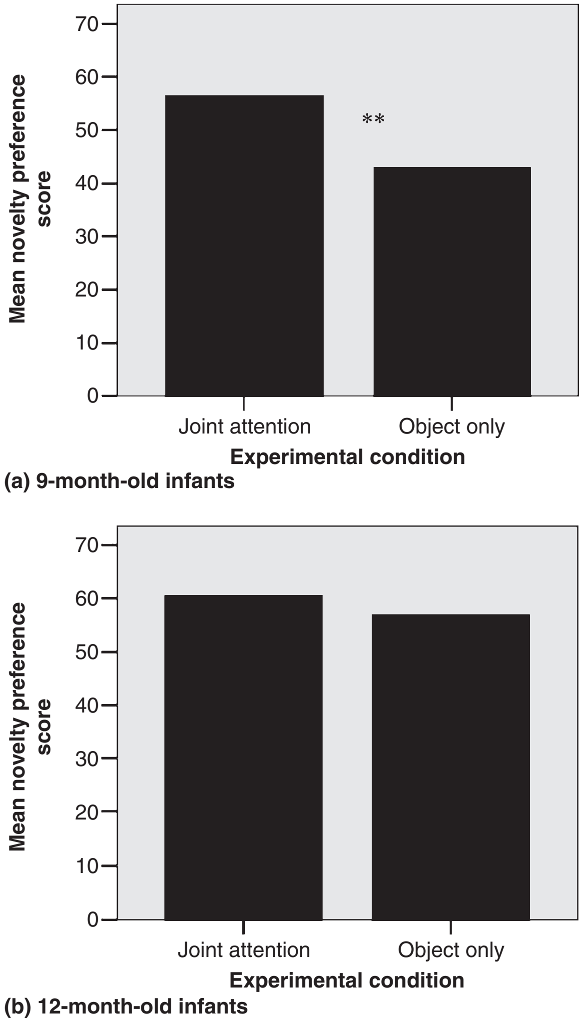

Figure 1.3. Novelty preference scores, for 9- and 12-month-old infants, following joint-attention and non-joint-attention (object-only) interactions
Source: Striano, Chen, Cleveland, & Bradshaw (2006).

Autism and Attending to Others

Work with very young infants shows that the ability to discriminate relevant triadic interactions from irrelevant triadic interactions is clearly an essential step in social-cognitive learning. Given the abundance of information that is always around infants, it is necessary that they are able to pick up on the cues that are most essential for effective learning. Persons with autism provide a clear example of what happens when parsing of relevant information is not possible for some reason (Klin & Volkmar, 1993). Individuals with autism are often reported to attend to irrelevant information in the environment. Imagine yourself at a dinner event. When you sit down at the dinner table, you will probably be attending to subtle social information. Indeed, you may very well be attending to social information (an eye gaze, the nod of your host, or seemingly universal language cues, "Bon appetit!") just in the hope that it will give you essential information about something that is non-social (that is, when to begin to eat). But the mere fact that we attend to these social cues implies that we constantly keep others in mind, and do not want to make the wrong impression. Now imagine being at the dinner table without having others in mind. You will probably pay attention to what is most interesting: if you are hungry, it will be the duck and potato, and, maybe, if you are not, it is the spoons on the table that produce novel sounds every time you bang them against your plate. These are much more pleasing and easy to control and manipulate than the voices of others. You can make the sounds stop and start as you please – if only you could do the same to the people talking around you. We use this example to illustrate the importance of using triadic social cues to gain information. It is one thing to detect these cues, and another to use them effectively. Understanding the drive to interact with others will be a key factor in establishing the origins of human social cognition and those factors that make it go awry somehow, as in the case of autism.

Joint Attention: A Fresh Look with New Methods and Perspectives

In parallel to research investigating joint attention, much research has been conducted into properties of infant electrophysiological responses to cognitive tasks. Most often these responses have been measured with event-related potentials (ERPs – also referred to as event-related brain potentials), the electrical brain activity that is time-locked to the onset of a stimulus (Rugg & Coles, 1995). Since 2000, knowledge of how the functional brain develops has increased dramatically (Johnson, 2005). One component of the infant ERP that is well mapped in terms of cognitive properties is the mid-latency *negative component*, or Nc. The Nc occurs approximately 300–700 milliseconds after stimulus onset, is most prominent at fronto-central electrodes, and is thought to relate to the development of memory and attentional processes during the first twelve postnatal months (Webb, Long, & Nelson, 2005). We have recently developed a new ERP paradigm that is instrumental in understanding the influence of social cues in early neural processing. Before turning to this paradigm, we review one of our first studies that led to it.

In an initial ERP study (Reid, Striano, Kaufman, & Johnson, 2004), we questioned how infants at 4 months processed objects that were cued by eye gaze. In this paradigm, infants viewed an adult's face on screen, with the eyes oriented forward. The eyes then gazed toward an object. Then the infants viewed the objects a second time, to which we time-locked our ERP measure. The infant ERP exhibited an enhanced positive slow wave for the uncued objects relative to the cued objects.

As the positive slow wave has been related to context updating in face-processing studies (e.g. de Haan & Nelson, 1999), the cued object was thus processed and more familiar to the infant than the uncued object. This study reveals in infants both a sensitivity to the detection of triadic cues as well as the functional use of this information by 4 months of age. This study involved the presentation of gaze on screen. It therefore assumed that the social relevance of gaze would be transferred to the infant, even though the gazing adult was virtual.

In a second study involving a live interaction between infant and adult experimenter (Striano, Reid, & Hoehl, 2006), infants interacted with an adult in two conditions. In the *joint-attention* condition, the adult looked at the infant and then at the computer screen, which then displayed an object. In the *non-joint-attention* condition the adult looked only at the computer screen while talking and vocalizing. An example of the set-up can be seen on Figure 1.4. For a trial to be included, infants needed to look at the adult and then to the object presented on the screen. We measured ERPs when infants were looking at the object presented on the screen. We predicted an enhanced Nc for objects that infants viewed in the context of joint attention compared to non-joint-attention contexts. Our results confirmed these predictions. We found that, at 9 months of age, the infant brain responded

Figure 1.4. ERP joint-attention procedure
Note: E = experimenter; I = infant.
Source: Striano, Reid, & Hoehl (2006).

differently toward objects that had been cued by joint attention versus non- joint-attention contexts. We found an enhanced negative component – which is an index of attention peaking around 600 ms after stimulus onset – for the joint attention condition. These results demonstrated the validity of this new interaction paradigm to understand how the infant brain processes information as a function of social cues. As ERPs can provide a more sensitive measure of the way that infants process information when compared to behavioral paradigms, could we also find signs that much younger infants were gaining something from joint-attention interactions? Recall that behavioral work had shown that, at 4 and 5 months of age, infants did not learn anything more about objects when they were presented in a joint-attention context. In a recent study, we asked whether 5-month-old infants processed objects more fully as a function of joint-attention contexts. In this study, infants interacted with an adult in two different ways. In one condition, the joint-attention condition, the adult looked at the infant's face and then to the object on the computer monitor and back to the infant. In the other condition, the non-joint-attention condition, the adult looked at the infant's chest and then at the object on the computer monitor and then back at the infant's chest. This way we were able to control for movement cues and facial information. What differed across conditions was that there was direct eye contact in the joint-attention condition but not in the non-joint-attention condition. Following an interaction phase in which infants saw objects in these two conditions, they were then presented with the objects. As in the prior study, we measured how the 5-month-olds' infant brains processed information as a function of social interaction. We found an enhanced Nc, about 400 ms after stimulus onset, when objects were presented in the context of joint-attention interaction when compared to those in the non-joint-attention condition (Parise, Reid, Stets, & Striano, forthcoming). These results paralleled what we had found with the 9-month-olds. What is important to recall is that, at 5 months of age, in the behavioral studies (Cleveland et al., 2007) we did not see evidence that infants used joint-attention cues to learn about objects. When we used a more sensitive measure, however, and in particular when we assessed how the brain was processing information in joint-attention contexts, the picture was different. The sensitivity to joint-attention cues was more than mere sensitivity to detection of differences in the social interaction; rather it was functional – at the neural level. These results are important, because they suggest that measures of neural activity can give us information about development that analyzing behavior alone cannot. This is important, not only for understanding the relation between brain and behavioral development across typical ontogeny, but especially for the early identification of infants who may be at risk of later social cognitive impairments such as autism. For example, we predict that an infant whose brain is not manifesting enhanced processing of relevant social information may be at risk of a range of impairments that are indexed through social-cognitive measures. We predict that these infants would have difficulty in parsing social information, in detecting the relevance of information, and in using these cues to interact and learn efficiently.

Conclusion

In this chapter we hope to have made just a few points. If we were not successful, here is our final attempt. The attainment of adult social cognition is a long process, and one that does not contain abrupt changes in ability. It is not as if an infant wakes up one day and begins to understand the internal mental states of other people. Over the first months of postnatal development, infants detect social cues provided by others. They learn that some of these social cues are more relevant than others and then use these cues to learn efficiently.

We have been able to show that, by 3 months of age, infants are sensitive to relevant dyadic as well as triadic social cues. Earlier in development, at 1 month of age, this is not the case. Further research is needed better to understand why this is the case. One possibility is that maturation and social experience are critical factors. Another alternative is that the paradigms that we have used are not sufficient to address whether young infants detect and interpret differences in social situations.

While our work has shown that even young infants are sensitive to some types of social cues, we were unable to explain why at times behavioral measures and neural processes did not tell us the same story. Why is it that 5-month-old infants failed to manifest behavioral signs that joint-attention cues aided in learning, while at the same time their ERPs showed signs of enhanced processing following joint attention? Is this a matter of measurement sensitivity? Or is the enhanced brain processing indexing some pre-manifestation of later behavioral signs? We hate to end our chapter with posing more questions than we have addressed, but that is the current state of affairs in early social-cognitive research. We have come a long way, but have much further to go before we can begin to put the pieces together.

Understanding the process of social-cognitive development will be important in understanding what makes it fail to develop in some cases – such as in the case of autism. This is no easy feat, but we hope to have demonstrated in this chapter that, in order to understand development, we need to study development. We must also be open to using multiple measures to address our questions and to use an interdisciplinary approach. The approach we have used in our own research is far from fully interdisciplinary, but we hope that an acknowledgment of our limitations, as well as an openness to new techniques and to various expertise from fields of neuroscience and psychopathology, will help as we tackle some of the most fundamental questions within the field of the development of human social cognition.

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