Social cognition in the first year

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Although the study of infancy has answered many important questions about the human capacity for social cognition, the relatively young field of developmental social cognition is far from reaching its adulthood. With the merging of developmental, behavioral and neurocognitive sciences, some growing pains are in store. New work demonstrates that research into early social cognitive development must integrate various research fields and methods in order to achieve a more robust understanding of the nature and parameters of human social cognition.

Overview
Social cognition refers to the ability to understand other people. The study of social cognition is inherently interdisciplinary. It includes everything from understanding the foundational perceptual skills that enable us to discriminate between people and objects, the complex interplay of social cues such as eye contact, body movements, tone of voice and facial expressions that help us to interpret the behavior of others, to the capacity and function of symbolic communication. Formerly, the problem of social cognition was left to social psychologists, neuroscientists, anthropologists and psycholinguists who tackled these questions among adults. However, recently, many developmental psychologists have started to address these questions. There is no better way to address a complex problem, such as that of understanding human social cognition, than to unravel its ontogeny. Here, we outline key aspects of early social cognition and describe their function and developmental trajectory. Starting with newborn infants and their predisposition to specific social information, we outline new research on how infants interact with others. We show that to best understand early social cognition, multiple methods must be used. Recent research in the field of early social cognition shows that the relationship between social cognitive skills and later abilities are more complex than was previously realized.

Dyadic (person–person) interaction
In the early months, infants primarily engage in dyadic, face-to-face interactions. These interactions are characterized by reciprocation of affect and emotions between social partners (Figure 1; dyadic). There are major changes at 2–3 months in the way that infants interact with others [1]. By the second month, infants begin to focus on the eyes and mouth of other people [2,3], and become distressed when others pose a ‘still-face’ and stop interacting with them [4]. Despite these transitions, newborn infants are far from asocial. Even hours after birth, infants have been found to look for longer at a face with a direct, compared with averted, gaze [5,6], an ability that will have an impact on the ability to interact with others, follow their gaze and learn about the world. Newborns are sensitive to faces, voices and eye contact [7] but do not appear to have particular social expectations or show reduced attention or affect towards a social partner who suddenly stops interacting. However, with only six weeks of interactive experience, infants show a classic still-face effect [8,9]. They reduce their smiling and gazing and then attempt to re-engage the social partner. They distinguish between an adult who interacts in a relevant way by providing contingent feedback, such as smiles and vocalizations, compared with someone who interacts in an irregular way, with delayed social feedback [4,10].

Within the first months, infants have had enough regular social experience to detect small perturbations — even a 1 second temporal delay — in the flow of interpersonal interaction [11–13]. Together with a sensitivity to social cues, such as eye-to-eye contact and vocal cues, by 3 months, infants have the skills to understand the relevance of the social signals necessary for learning and communication [14] (Box 1). However, many questions still remain about the early foundation of social cognition.

Given the limited attentional state of newborns, answering such questions is easier said than done, and makes it important to design optimal experimental situations in which infants can respond. Null results do not mean that a behavior or capacity for understanding does not exist. However, we might be more willing to conclude that younger infants have fewer capacities than do older ones, rather than questioning the sensitivity of the methods used or speculating on the mechanisms that might give rise to more mature social cognition. Identifying the mechanisms of change should be among the major tasks for developmental scientists. An example can be found with the recently addressed question: do six-month-olds show evidence of differentiating the intentional from the accidental actions of an adult? Behne et al. [15] addressed this topic by comparing the behavioral responses of six-, nine-and 18-month-old infants’ towards an adult who played with them. In some cases, the adult was suddenly unwilling to give the infant a toy (i.e. teasing); in other cases, the adult was unable to give a toy (i.e. accidentally dropping). The authors measured how much infants looked away from

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Box 1. Detecting and identifying the parameters of others

The investigation of biological motion is important for social cognition. Behavioral research with infants suggests an early capacity to detect and interpret biological motion. This is shown by a preference to attend to biological motion when compared with other moving stimuli [42]. This research is typically conducted with point-light displays (PLDs), depicted by points of light moving as if attached to the major joints of a moving person. PLDs are often used because a minimum amount of information is provided on what is represented by the dots.

Research into infant perception of biomechanical motion suggests that even three-month-old infants are able to discriminate some aspects of biological motion from other forms of motion [42]. Recent research has focused on neural mechanisms associated with the perception of biological motion. These studies have found that eight-month-old infants appear to process biological motion in the same manner as do adults, when compared with scrambled motion [43]. In another study, upright and inverted biological motion stimuli were presented to infants [44]. The ERP indicated a right parietal positivity for the upright but not the inverted PLDs. Even though the morphology of the infant ERP is ontogenetically unique, the topographical distribution and the latency suggest that infant and adult perception of biological motion are similar at the cognitive level [45,46].

Advocates of PLDs argue that little information is provided in terms of the underlying schematics of the represented object or individual [47]. A central problem is that to perceive that certain PLD movements are ‘biological’, some underlying parameters of the depicted organism must be understood. However, it is argued that infant human body knowledge is poor at best. For example, only 18-month-old infants dishabituate when presented with simple corruptions to body schema [48,49]. Such disruptions include removing arms and legs and placing the limbs in the alternate limb location (Figure 1). When adults observe the same images, the recognition of schematic disruption is virtually instantaneous. Thus, the conflict between the detection of biological motion and the corruption of body schema might be the result of the task indexing different aspects of the observed agent, potentially explaining why ERP studies suggest that infants might encode the structure of the human body [50]. Further research might resolve these issues in early social cognition.

Figure 1. Schematically possible (top row) and impossible (bottom row) images of the human body. Infants younger than 18 months fail to discriminate between these two conditions, suggesting a lack of understanding with respect to the normal configuration of the human body. Reproduced, with permission, from Ref. [48].
the adult and reached for the object. The results showed that six-month-old infants did not differentiate between an adult who was unwilling or unable to give them a toy – suggesting that they could not distinguish the intentional from the accidental actions of others. However, the amount of time that infants looked at the adult, and the way that infants communicated toward the adult (such as by looking at the adult while vocalizing positively or negatively) might be a better measure of the competencies of infants. Furthermore, how do we explain that adult chimpanzees distinguish between unwilling and unable actions using a similar paradigm [16]?

The interpretation of dyadic behavioral cues present in the way that other people move, talk and relate is probably a predominant means by which we infer the mental states of others [18–20]. A sensitivity to dyadic cues might also be crucial in the identification of infants with communicative impairments, such as autism (Box 3).

A key transition in early development is from participating in face-to-face (dyadic) interactions to engaging in person–object–person (triadic) interactions. Triadic interactions involve two people in relation to some third external object, situation or event. These interactions are essential for the development of abilities such as language and imitation [21,22]. For instance, as shown in Figure 1 (triadic), to learn the name for a novel object, the infant must be able to detect when the interactive partner is communicating relevant information directed at the self, and to what this information refers. Because of the inclination for dyadic face-to-face interaction in the early months, it has been assumed that young...
infants are simply not capable of engaging in triadic interactions. Based on studies that considered infants’ capacity for joint attention only at nine months of age and later [23,24], it has been concluded that the capacity for joint attention emerges at nine months of age or later. Recent research with infants under nine months of age tells a different story. By five months, infants actively coordinate visual attention between people and objects [25,26]. Although it is clear that there are developmental transitions toward the end of the first year, the basis of these developments is simply not understood.

**Joint attention: so what’s the early function?**

Only recently has the infant’s capacity for triadic interaction been investigated. In one recent study, three-, six- and nine-month-old infants interacted with an adult and objects. The infants and the adult interacted in a dyadic way, and then different types of triadic interactions were introduced. By three months of age, infants discriminated among various triadic interactions [27]. But why should infants be sensitive to triadic attention if it is not functional? Some might conclude that a three-month-old infant cannot use the visual attention of others to learn language, new actions or about the world. The fact of the matter is that these issues have not been addressed. There is some evidence to suggest that a sensitivity to triadic attention, even in three- to four-month-old infants, is functional [28]. This makes sense because research shows links between the capacity for triadic attention (i.e. gaze following) at ten months and language capacities at 18 months [22,29]. However, we need to know much more about how social sensitivities in early development might relate to, and predict, later cognitive functioning. What we do know is that even four-month-old infants are attuned to the eye gaze of others and use eye gaze cueing in processing objects. In one study [30], four-month-old infants watched a video presentation of an adult gazing towards one of two objects. When presented with the same objects a second time, infants gazed towards the uncued object for a significantly longer period of time – suggesting that it was more novel. This means that four-month-old infants not only followed the gaze of the adult, but also acquired information about the object.

Beyond sensitivity to eye-gaze cueing, triadic cues assist infants in object processing. In general, joint attention helps young infants to establish the relevance of social information. Cues such as eye contact [31] and tone of voice [32] help infants to establish when information is intended for them. They can then use these cues to guide their attention towards the world and to learn more effectively. Evidence from the brain activity of infants supports this view. Reid et al. [33] investigated object processing among four-month-old infants in an event-related potential (ERP) study. Infants viewed an adult’s face onscreen, and the eyes of the adult gazed at an object. In the test trials, infants viewed the objects for a second time. Infants rapidly exhibited enhanced neural processing (indexed by a positive slow wave) of the uncued object during test trials. Thus, the cued object was processed and more familiar to the infant in the test trials than was the uncued object. This study reveals both a sensitivity to triadic cues and their functional use by four months of age.

One of the challenges facing infancy researchers is how to design effective paradigms that best reveal what developing infants can do and what they might be capable of processing. To determine what infants understand, it is important to make a distinction between the infants’ sensitivity to social information and their capacity to initiate or produce social communication. Considering these two domains separately might contribute uniquely to our understanding of human social cognition (Figure 1). For instance, take the problem of assessing the neural correlates of social cognition using computer-displayed images, and when presenting people as stimuli over television. It is known that children do not treat television images as live events [34,35] and that the infant brain processes two-dimensional and three-dimensional stimuli differently [36]. These findings are consistent with research showing that mirror neurons in monkeys fail to fire when observed actions are presented via television [37]. To overcome the problems associated with unnatural social events, it is necessary to design studies that optimize the attention of infants and keep social interaction as natural as possible. In this regard, the development of the first live-interactive paradigms to study how the infant brain processes information has proven successful [38]. However, far more research is required to understand how stimulus materials interact with the development of social cognitive skills.

**Interactive ERP paradigms**

In one recent study, the neural correlates of triadic attention were assessed in nine-month-old infants [38]. Infants faced a computer monitor. An adult sat across from the

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[Figures: Event-related potential responses to observing an object in a joint attention (JA) condition (gray) and a nonjoint attention condition (black). The joint attention condition produces a larger amplitude negative component when compared with the no joint attention condition, peaking at 400 ms after stimulus onset. This suggests a greater allocation of attentional resources by the infant during the joint attention interaction. The labels indicate the electrode site in the international 10–20 EEG system. ‘F’ channels are frontal and ‘C’ channels are central scalp sites. Reproduced, with permission, from Ref. [31].]
Box 4. Questions for future research

- How do infants learn about the relevance of social signals?
- What brain mechanisms are involved in the detection of relevant social signals, and how does this process work in typically developing infants and those with social cognitive impairments?
- What is the role of eye gaze and other social cues in early learning?
- What are the universal social cues to which infants are sensitive?
- What are the main components of dyadic interaction, such as eye gaze, vocalizations, head orientation and physical contact, and what is their order of importance for social cognition as a function of development?
- During triadic interaction, what initial information is important for understanding referential looking between a person, an object and the self?
- How do infants at risk for autism process discrete aspects of dyadic and triadic interactions, such as eye gaze cueing or vocalizations?
- When does the biological motion detection system mature?
- What is the relationship between detecting biological motion and detecting body schema?

Infants and interacted in various ways. In a joint attention context, the adult gazed at the infant’s face and then to a novel object that was displayed on a computer screen for 1 second. In the joint attention context, the adult gazed only at the novel object. Within a period of 5 seconds, and for each trial included in analysis, infants looked at the adult’s face and then to the novel object on the screen. The electrical brain activity of the infants was then measured as they viewed the novel objects presented on the computer screen.

The infant brain processed objects differently depending on social context. As shown in Figure 2, the negative component of the infant event-related potential, a neural correlate indexing attentional processes [39], was enhanced in amplitude (red line) when infants were engaged in a joint attention interaction compared with a nonjoint attention interaction. Given the interplay between joint attention and later cognitive skills [40,41], the results suggest a general learning mechanism that might underlie a range of cognitive developments. To ascertain whether this is the case, such paradigms should be applied to a range of cognitive skills. Whatever the outcome, the application of ERP techniques to social situations stands to greatly inform the wider developmental sciences and help to resolve the many questions that remain on early social cognition (Box 4).

Summary

We have outlined recent advances in our understanding of early social cognition. It has been found that young infants have many of the rudimentary skills needed for more mature aspects of social cognition. Through the study of early development, it is possible to understand what types of experiences and maturations are necessary to learn from and relate to others, including predicting and interpreting the behavior of others. Many social cognitive milestones have been established but we need now to understand the mechanisms of developmental change and how these account for brain and behavioral functioning at different ages. Understanding the mechanisms of development is an interdisciplinary problem that demands the study of infancy and the integration of fields such as neuroscience, social psychology and anthropology. Finally, it is only through the use of multiple methods that new insights into the development of the infant mind will be found.

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