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Early Intention Understandings that are Common to Primates Predict Children's Later Theory of Mind

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Summary

Intention understanding emerges early in human development, manifest in deep and robust fashions even in infants. Overlapping intention understandings, encompassing agents as intentional actors and experiencers, are evident in nonhuman primates in more limited fashions. Intention understandings, of the sort shared by infants and nonhuman primates, predict the more comprehensive theory-of-mind understandings of older children. Those early understandings provide a platform for the ontogenesis of further, deeper achievements in the human case.

A complex organism (e.g., person, monkey) is a solid physical body, a biological, a social, and an intentional entity (acting deliberately on the basis of intentions, desires, beliefs). Humans understand self and others in all these ways. Here we focus on intention understanding, everyday understanding of agents in terms of their internal mental states, often termed "theory of mind". Intention understanding emerges early and universally in the human case, leading to tremendous current interest in its developmental and evolutionary origins. Neatly, researchers have addressed several of the exact abilities of interest to infant researchers with nonhuman primates (hereafter, primates), at times using very similar paradigms.

Infant Intention Understanding

Consider Box 1 and the experimental logic outlined there. When 8-, 9-, 10- and 12-month-olds see such displays in looking-time studies, they consistently look longer at the indirect test events. They do so for live [1] and videotaped human actions [2,3], and even for animated geometric shapes "jumping" over barriers to join other shapes [4]. Infants look equally to both test events in control conditions in which they are first habituated to a display with either no barrier or no goal-object. Complementary findings come from more active/interactive paradigms. In one illustrative study[5], a woman passed toys across a table to an infant. Interspersed were trials where she did not pass the toys because she was either *unwilling* to or *unable* but trying to (e.g., could not extract it from a container) do so. Nine- to 18-month-olds behaved more impatiently (e.g., reaching, turning away) when the woman was unwilling than when she was unable to give them the toy. Although the surface

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behaviors were similar and the outcomes identical, infants distinguished between these intentional actions.

Box 1

Habituation-test (or familiarization-test) paradigms are designed so that participants will look longer at novel, unexpected test events more than at familiar, expected test events. In the reaching paradigm (depicted above), during habituation, participants view multiple trials of the agent reaching over the barrier for the goal object. Then, the barrier is *removed* and the test events contrast two different construals of the person's actions, one in terms of intentions and one in terms of physical motions of the body. If during habituation participants construe the actor's action in terms of its physical movement (the arcing arm motion), then the indirect reach test event should be expected (as it repeats the same movement) whereas the direct reach will stand out as novel and so especially attention-worthy. In contrast, if participants initially construe the action as goal directed (the actor going as directly as possible to get her goal), then when the barrier is removed the direct reach would be the expected action because the actor continues to directly seek the goal, and the indirect reach would be more attention-worthy because (although the actor's arm movement remains the same as during habituation) the action is no longer straightforwardly directed to the goal. In this paradigm, 8-, 9-, 10-, and 12-month-olds and chimpanzees and macaques consistently look longer at the *indirect* test event.

When viewing actions like those in Box 1 infants might identify only the object-directedness and objective efficiency of the overt behavior toward the target-object — a teleological or behavioral rather than intentional understanding [6]. But, inferring a goal when it is unfulfilled and thus non-overt in the action's movements or outcomes demonstrates an understanding of intentions beyond the surface behaviors performed. In a seminal study [7], after witnessing an adult fail at several novel, object-directed goals (e.g., hanging a ring on a hook), 15- and 18-month-olds "imitated" the (never seen) successful actions much more than the failed (though actually witnessed) actions. Motoric imitation is arguably a demanding response system; so, consider a version of Figure 1 where the actor reaches for but falls short of successfully grasping the target object. If habituated to such unsuccessful actions 10- and 12-month-olds, but *not* 8-month-olds, interpret the actions in terms of the (never actually seen) intentional goal of directly grasping the object [2].

In the wider philosophic sense "intentionality" encompasses not just goal-directed action, but a distinctive kind of subjective orientation of beings to the world, including intentional experience. Seeing (visual perception) is a prime example of intentional experience. Potentially, gaze following, where infants follow an agent's line of sight (or head orientation) toward an object, could be produced by an understanding of what the agent sees. But gaze following can also be achieved behaviorally, without an understanding of the agent's visual experience, by matching a head turn or direction of gaze. By 12- to 14-months, however, infants follow an adult's gaze around a barrier — even if this requires leaning or moving behind the barrier to verify that they are seeing the same thing [8].

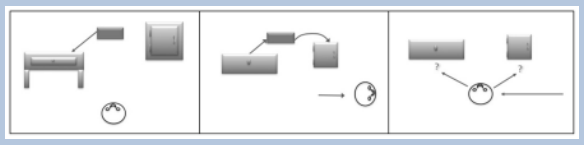
Recent data confirm a deeper understanding of visual experience. At 12 months, infants often "gaze follow" the head turns of adults who wear blindfolds. But when given advance

experience with blindfolds occluding their own vision, they are less likely to follow the "gaze" of a blindfolded adult, suggesting that their sense of what the adult actually sees guides their actions. Eighteen-month-olds rarely follow the gaze of blindfolded adults — they understand blindfolds occlude visual experience; but upon encountering a special blindfold that looks opaque, yet is easily seen through when worn, 18-month-olds do follow the gaze of an adult wearing that blindfold. Thus, by 12 to 18 months, infants' sense of a person's visual experience (not just overt eye- or head-directedness) controls their actions [9].

Moreover, year-old infants understand that intentional experiences accumulate in ways that provide an initial sense of an agent's knowledge (and ignorance). In a recent study [10], infants interacted with three objects. Critically, a target adult joined in these interactions for two of the objects, but was absent for the third. After these interactions, the target adult saw all three objects displayed on a tray, and said to the infant, "Wow! That's cool! Can you give it to me?" Three objects were now familiar for the infant, but one was new (and so "cool") to the adult. Twelve- and 18-month-olds gave the adult the object that was new for him. Thus, they tracked the adult's experiences sufficiently to know his experience was not updated (when theirs was). In doing so, infants revealed some understanding that the adult was ignorant or previously unaware of the third object.

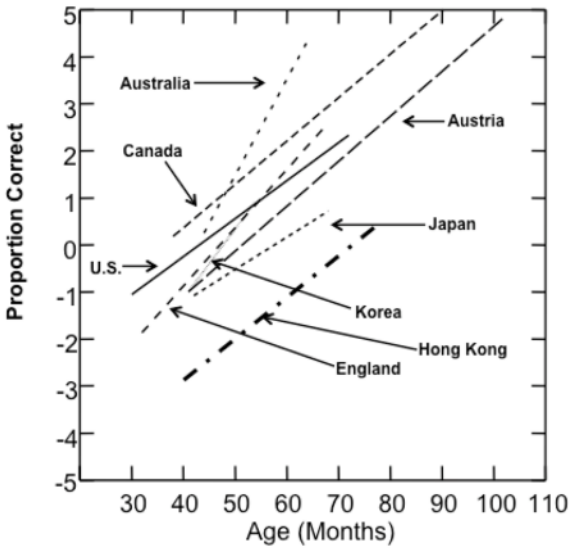
During the preschool years, children come to additional theory-of-mind achievements. In particular as outlined in Box 2 they come to easily pass and explain a variety of standard false belief tasks [11]. Indeed, some research concludes that even infants understand false beliefs [12,13]. But, these looking-time data have alternative explanations. In particular, infant looking could arguably be due to an understanding that the agent is ignorant or unaware (rather than possessing a specific false belief). For now, therefore, we prefer an interpretation that describes intention understanding at around one year as revealing understanding of agents in terms of intentional actions and intentional experiences (including the experience of ignorance or being unaware, but not including an understanding of false beliefs).

Box 2



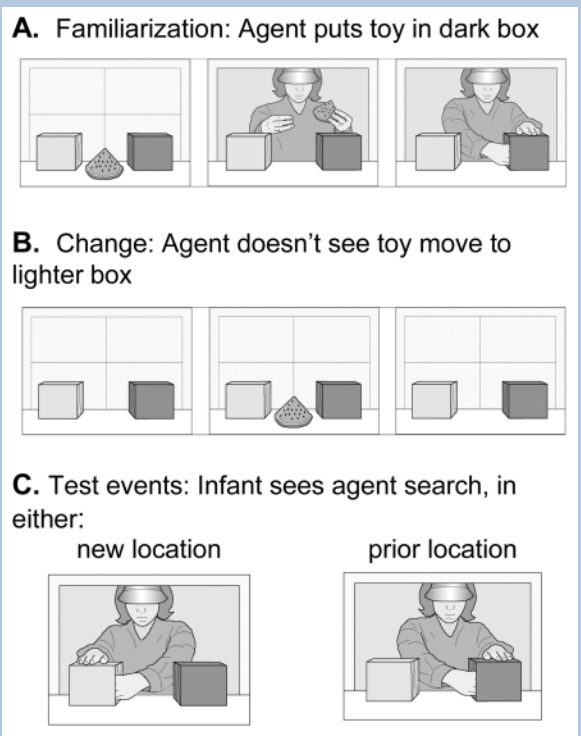
False belief tasks have children reason about an agent whose actions should be controlled by a false belief. A common task employs a change in locations, as depicted above. The child (not shown above) sees the character put his chocolate in one location. The character leaves and while he cannot see, the chocolate gets moved. When the character returns the child is asked "Where will he look for his chocolate?" or "Where does he think his chocolate is?" Older children (5 years and over in many studies) answer correctly, like adults. Younger children answer incorrectly. They are not just random; they consistently say the agent will search in the new location (where it really is). Note that the task taps more than just attribution of ignorance (agent doesn't know where his chocolate is); rather it assesses attribution of false belief (agent thinks — falsely — that his chocolate is in the drawer).

As shown in the graph at left, children in different cultural-linguistic communities achieve false belief understanding more quickly or more slowly, yet in all locales they evidence the same trajectory — from below chance to above-chance performance typically in the preschool years[11].



Infant False Belief Understanding?

Recent research claims that the intention understanding of one-year-old infants also includes false belief understanding. The initial and most well-known demonstration comes from Onishi & Baillargeon [12], in a familiarization-test paradigm schematized here. In essence, paralleling standard tasks (above), infants see that the agent places the object in one location and does not see the object switch locations. If infants expect the agent to search in the prior location (on the basis of a false belief), they should look longer at the new-location test event. 15-month-old infants do consistently look longer at new location-test events.



Note, again, however, that understanding false belief requires more than just understanding ignorance. So, alternative interpretations are possible based on an infant understanding of ignorance rather than false belief. For example, if infants understand the agent is unaware (and thus ignorant of the location of the object), that understanding would be sufficient for them to see the new-location test event as novel or unexpected (e.g. if the agent is ignorant, she might search in neither place, she might search in both places, she might search incorrectly, but in any event it would be novel/unexpected to see her search directly in only the correct location.)

Predictions to Later Theory of Mind

Children in the preschool years evidence not only robust, explicit understandings of false belief, but also many other theory-of-mind achievements [14]. They judge mental entities (thoughts, dreams) as not-real. They understand explicit mental-physical distinctions: If told about someone who has a dog versus someone who is thinking about a dog, they know which dog can be petted and seen and which is just made-up or “in the mind”. Preschoolers come to understand and practice lying and deception. Arguably, these preschool achievements represent increasingly deep intention understandings continuous with precursory infant understandings. Indeed, several studies now show that how long infants attend to intentional action, in displays like those in Figure 1, predicts their later performance on false belief and other preschool theory-of-mind tasks [15,16]. Is this continuity specific to the domain of social cognition or does it represent continuity in more general cognitive processing (e.g., IQ, memory encoding, executive functioning)? In the most comprehensive study to date, infant attention to intentional action at 10- to 12-months predicted theory-of-mind understanding at 4-years even when IQ, language competence, and executive functioning at 4-years were controlled [17]. Moreover, in a recent study, infant attention to physical-action displays did *not* predict later preschool theory of mind [18]. Thus, intention understanding shows distinctive infant-to-preschool continuities; infant *intention* understanding is formative for further developmental advances in theory of mind.

Primate Intention Understanding

Until recently it seemed that primates construed agents in social-behavioral ways with very little, if any, understanding of them as intentional agents. However understanding of intentional action has been confirmed in primates [19]. Reconsider Box 1. Following familiarization with events in which a human agent reaches in an arcing path over a barrier that separates it from a goal object, macaque monkeys looked longer at the indirect than the direct test event [20]. In control conditions, after familiarization with actors displaying the same acts with no barrier, macaques looked equally at the indirect and direct test events. These findings support the view that, like human infants, primates possess a basic understanding of the goal-directedness of action.

Complementary data again come from more active/interactive paradigms. In extensions of the unwilling-unable paradigm described earlier, chimpanzees produced more begging behaviors and left the testing room earlier when an experimenter was unwilling to give them food (e.g., offering and withdrawing a grape teasingly) than when she was unable but trying to give them food (e.g., repeatedly dropping the grape) [21]. Similarly, capuchins left the testing station sooner in response to the actions of an unwilling compared to an unable experimenter [22]. Although the experimenter’s actions were nearly identical at the surface, chimpanzees and capuchins recognized a difference between the underlying intentions.

Primates’ understanding of intentional experience has also been studied. Many primates spontaneously follow the gaze or head orientation of conspecifics or humans. Although it is

unlikely that most primate species follow gaze because they understand the nature of visual experience, great apes probably do. In controlled situations chimpanzees, bonobos, gorillas, and orangutans all follow gaze to distant locations and around barriers (even when it requires physically reorienting their bodies), and visually check back to verify the direction of the looker's gaze [19].

Data on primate understanding of visual experience is particularly strong for chimpanzees and in contexts of food competition. In early research using cooperative-communicative paradigms (in which an experimenter's goal was to share food with the chimpanzee), primates performed poorly and failed to demonstrate awareness of the intentional experience of others [23]. In paradigms involving competition for food, however, chimpanzees perform much better [24].

Consider: A piece of food is hidden between a dominant and a subordinate chimpanzee and, as a result of the positioning of certain obstacles, the chimpanzees have different visual access to the food. When the subordinate could see two pieces of food and the dominant could see only one, the subordinate preferentially targeted the less-risky food that the dominant could not see [25]. Studies further suggest that chimpanzees demonstrate these preferences because they understand something about the link between seeing and knowing: Chimpanzees adjust their behavior not only on the basis of what others currently can and cannot see, but also on the basis of what they have and have not seen in the past — what others know or do not know. Subordinates preferentially targeted an occluded piece of food that the dominant was ignorant of (had never seen) or misinformed about (had seen in one place but had not seen moved [26].

These abilities are probably not unique to chimpanzees. Rhesus monkeys also show impressive sensitivity to experimenters' perception and perceptual experiences in competitive situations [27].

In the human case, functional neuroimaging, neurophysiology, and lesion studies have identified a network of brain regions associated with theory of mind and intention understanding. These regions include the medial prefrontal cortex, the temporo-parietal junction, the superior sulcus, and the temporal poles [28,29]. Some of these systems appear to be uniquely human, but premotor mirror neuron systems are evident in both humans and primates. One intriguing possibility is that mirror neurons enable intention understanding (more so or in addition to imitative behavior or simulative reactions more specifically) [30].

Although chimpanzees (and some monkeys) understand action as intentional and understand something about the visual experience and even knowledge of others, primates' intention understanding falls short of children's. First, primates' understanding may be limited to competitive contexts, not more broadly applicable (e.g., to cooperative situations), as in children. Second, there is no evidence that primates go beyond the distinction between knowledge and ignorance to represent the false beliefs of others, even in competitive situations [31]. Third, the strongest evidence often comes from "enculturated" primates — primates with much experience with humans. Finally, in the human case, intention understanding and theory of mind are revealed in numerous acts of pointing, showing, and teaching [32]; yet there is little if any evidence for anything like teaching in nonhuman primates.

Conclusions

Intention understanding emerges early in human development, manifest in deep and generative fashions. Overlapping intention understandings, encompassing agents as intentional actors and intentional experiencers, are evident in primates in more limited

fashions. Early intention understandings, of the sort shared among primates, predict the theory-of-mind understandings of 4-year-olds. That is, those early understandings provide a platform for the ontogenesis of further, deeper achievements in the human case.

We know very little of the ontogenesis of any such skills and understanding in primates (for an intriguing exception see [33]). Thus, our analyses and those in the field are based on essentially three groups: human adults (and older children), human young (infants, young children), and primate adults. But, full comparisons include at least: primate adults, human adults, human young, and primate *young*. What if we found that for primates intention understandings were mostly late-developing, mature insights often limited to animals with extensive training or provisioning by humans? Such a finding, intriguing in itself, would change our sense of how to best understand the philogenesis and ontogenesis of intention understanding. Emerging research on intention understanding, with infants and primates and with creative behavioral and neuroscience methods, will help further unpack the overlapping phylogenetic and ontogentic origins of complex human social cognition.

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